MACHINE DESIGN

MARCH 1955

Fractional Horsepower Motors

ALLIS-CHALMERS

CONTROL

. . . Backed by Wide Application Experience

As manufacturers of *diversified* industrial equipment, Allis-Chalmers has been called upon to solve control application problems in practically every industry. This specialized experience in coordinating power utilization is *yours* when you specify Allis-Chalmers control.

The Allis-Chalmers line includes control for every condition of motor operation. Functions include full or reduced-voltage starting, acceleration, speed control, reversing or non-reversing, and dynamic braking. Built into Allis-Chalmers control is the type and degree of protection dictated by the application. Controls are available in general-purpose and special enclosures.

A-4587

● For help on a specific control application, call your Allis-Chalmers representative. His recommendations are backed by Allis-Chalmers engineering departments . . . by experience gained in solving thousands of control problems . . . by complete research and testing facilities.

ALLIS-CHALMERS

MILWAUKEE 1, WISCONSIN

THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

MARCH 1955
Vol. 27—No. 3

EDITORIAL STAFF

COLIN CARMICHAEL, *Editor*
BENJAMIN L. HUMMEL, *Associate Editor*
ROBERT L. STEDFELD, *Associate Editor*
LEO F. SPECTOR, *Associate Editor*
KEITH A. CARLSON, *Assistant Editor*
ROBERT C. RODGERS, *Assistant Editor*
JOHN B. HOLT, *Assistant Editor*
LAURENCE D. SHERGALIS, *Assistant Editor*
JANE H. SMITH, *Assistant Editor*
FRANK H. BURGESS, *Art Editor*
ROGER W. BOLZ, *Contributing Editor*

New York ..... B. K. PRICE, L. E. BROWNE
Detroit ..... FLOYD G. LAWRENCE
Chicago ..... ERLE F. ROSS, WILLIAM E. DEAN
Pittsburgh ..... ROBERT M. LOVE
Washington ..... E. C. KREUTZBERG
London ..... VINCENT DELPORT

REGULAR DEPARTMENTS

Over the Board	4
Index	7
Engineering News Roundup	12
Meetings and Expositions	49
Men of Machines	55
Industrial Design	187
Helpful Literature	223
New Parts and Materials	228
Engineering Dept. Equipment	290
The Engineer's Library	298
Stress Relief	308
Noteworthy Patents	316
New Machines	326

USE POSTAGE-FREE CARDS FOR:

INFORMATION
on products advertised 33

EXTRA COPIES
of editorial articles 207

ADDITIONAL DATA
on new products and methods 223

What's My Line? ..... *Editorial* 143
Is there a common yardstick for professional recognition?

Designing Special Machines ..... *By Alex Brunner* 144
A practical approach to design and development of machines for in-plant use

Scanning the Field for Ideas 149
Stamped rocker arms—plastic snap nut—constant horsepower drive—gyro wheel

Fractional-Horsepower Motors ..... *By Fred L. Olson* 152
Design considerations in the selection and application of small motors

Chromium Plating Thickness ..... *By J. B. Mohler* 161
Specifying coatings for decorative and engineering applications

Design with Tubing ..... *By W. O. Nussear Jr.* 165
How to design tubular machine components

Precision Gearing ..... *By G. W. Michalec* 174
Part 3—Inaccuracy sources and their evaluation

Knurling ..... *By C. T. Appleton* 181
Production and Design—Design factors in specifying knurled surfaces

Hydrostatic Lubrication ..... *By T. L. Corey and E. M. Kipp* 189
Basic theory and practical applications for hydrostatic bearings

Integrally Stiffened Structures ..... *By B. Saelman* 197
Design and producibility considerations for one-piece panel sections

Unit Weights of Metals ..... *By G. Sorkin and W. H. Hawley Jr.* 205
Data Sheet—Tabulation of over 240 ferrous and nonferrous metals

Impact Thermosetting Plastics ..... *By Paul E. Fina* 208

Germanium Rectifiers ..... *By H. N. McIntyre* 211

Fundamental Computer Mechanisms ..... *By J. Harland Billings* 213

Solid Particles in Oil ..... *By H. G. Rylander and E. M. Wight* 216

Cast-Weld Construction ..... *By G. J. Gibson* 218

Contemporary Design

Water coolers	171	Power mower	188
Facsimile printers	172	Industrial truck	204

Over the Board

More Steam

After our January "Over the Board" item on early steam cars, we learned of several steam cars produced earlier than the 1860 date mentioned. Thjor Ljunggren of Bryant Chucking Grinder Co. writes, "Approximately forty years earlier a Mr. Blanchard was "getting up steam" in a car designed and built by him. With this he 'plowed' the roads between Springfield, Massachusetts and Hartford, Connecticut. However, the roads at that time were merely tracks and Mr. Blanchard soon had to abandon his attempt to compete with Ol' Dobbin. Blanchard, so the story goes, was more successful with a water borne steamer and plowed the Connecticut river from aforesaid Nutmegger's Capital to the then recently abdicated capital of the Republic of Vermont—Windsor.

"As a boy Blanchard invented an apple-paring machine, the principle of which still can be recognized in that kind of appliance you buy today. . . . Man Blanchard happened to become the grand'dad of modern automatic tool machinery. . . . In the bloom of his manhood, he was assigned to the job of whittling gun stocks and, finding it tedious, he invented and built the first automatic tool machines—a copying lathe—with the result that he could singlehanded beat a dozen to a score handpicked, Champion Yankee Whittlers."

Also, we found out that a New York inventor, J. K. Fisher, tested a small steam carriage 102 years ago. It had two cylinders, a "water tube boiler," and would run "15 miles an hour on good roads."

Need a "Regretter"?

At a meeting of our planning committee for this year's Conference on Mechanisms, we heard from C. G. Bigelow of an extremely handy work-saving device called a "Regretter" by its inventor, Al Charpentier of AMF. This indispensable gadget helps you out when you make a mistake. All you do is push a button, and the machine utters, in clear, bell-like tones, "tsk—tsk—tsk."

This Month's Cover

That swirl you see on the front cover this month is George Farnsworth's portrayal of the power and speed of fractional - horsepower motors. These small motors pack a lot of wallop in small space, and are often designed for the specific application. For a good review of the factors involved, see Fred Olson's article on Page 152.

MACHINE DESIGN

Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD
Business Manager

Advertising

New York 17 ..... 60 East 42nd St.
Russell H. Smith, Alan C. Bugbee
James A. Stongorone
Murray Hill 2-2581

Cleveland 13 ..... Penton Bldg.
Jack W. Walton
Main 1-8260

Detroit 26 ..... 1249 Washington Blvd.
Woodward 3-3488

Chicago, Ill. ..... 520 North Michigan Ave
Howard H. Dreyer, Robert Z. Chew
Whitehall 4-1234

Los Angeles 48 ..... 6262 Commodore Sloat Dr.
F. J. Fuller
Webster 1-6865

San Francisco 4 ..... 57 Post St.
F. J. Fuller, Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. ..... 331 South Twelfth St.
Fred J. Allen
Griffin 7854

London, S.W.1 ..... 2 Caxton St., Westminster

Mary L. Callahan
Advertising Service Manager

Richard J. Strnad
Production Manager

Research & Promotion

Richard A. Templeton, *Research Manager*
George J. Auner, *Statistician*
Virginia R. Homad, *Staff Assistant*

Circulation

Pauline J. Herndon, *Manager*
Amy Lombardo, *Directory & List Dept.*

Published by
THE PENTON PUBLISHING COMPANY

G. O. HAYS ..... *President and Treasurer*
R. C. JAENKE ..... *Executive Vice President*
F. G. STEINEBACH ..... *Vice President and Secy.*
F. O. RICE ..... *Vice President*
J. P. LIPKA ..... *Asst. Secy. and Asst. Treas.*

Also Publisher of
STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

Published on the seventh of each month. Subscription in the United States, possessions, and Canada: One year $10. Single copies, $1.00. Other countries one year, $20.

Copyright 1955 by The Penton Publishing Company.

Accepted as Controlled Circulation publication at Cleveland, Ohio.

BPA NBP

INDEX

Advertising and editorial content itemized for convenience when studying specific design problems

A

Adhesives, Adv. 311
Aluminum and alloys, Adv. 114, 322, 327, 364
Automobiles, 1955, Edit. 16

B

Balls, Adv. 55
Bearing materials, Adv. 92
Bearings, ball, Edit. 228, 318; Adv. 11, 32, 119, 222, 341
  needle, Adv. 221, 285
  railroad, oiled by conveyor, Edit. 45
  rod-end, Adv. 131, 330
  roller, Adv. 63, 65, 119, 128, 221, 222, 281, 285, 341, 343
  sleeve, Edit. 228; Adv. 17, 31, 51, 217, 239
Bellows, Adv. 40, 278
Belts, conveyor, Adv. 296
  transmission, Adv. 86, 235, 288, 315, 355
Bolts, T-slot, Edit. 264
Books, Edit. 298; Adv. 45, 349, 357, 363
Booster, air-hydraulic, Adv. 95
Brass (see copper and alloys)
Bronze (see copper and alloys)
Bulb, photoflash, has glass base, Edit. 36
Bushings, Adv. 31, 239
  ball, Edit. 262

C

Cams, Adv. 284
Capacitators, Edit. 262
Carbon and graphite parts, Adv. 57, 92
Cast-weld construction, Edit. 218
Castings, centrifugal, Adv. 26, 125, 280
  die, Adv. 26, 122
  investment, Adv. 125, 136, 302, 332
  iron, Adv. 246
  non-ferrous, Adv. 102, 354
  sand, Adv. 26, 125
Chain, conveyor, Adv. 128, 247
  transmission, Adv. 66, 98, 128, 247
Chromium plating, Edit. 161
Classified ads, Adv. 310, 317, 356, 357
Clutches, Edit. 230, 260, 269, 320; Adv. 62, 238, 252, 269, 350, 361
Coatings (see finishes)
Coatings, protective, Adv. 54
Compressors, Adv. 85, 272
Computer mechanisms, Edit. 213
Connectors, electric, Edit. 266; Adv. 15, 56
Contactors, Edit. 234; Adv. 257, 294
Contests, Edit. 14
Control systems, hydraulic, Adv. 134
Controls, automatic, Edit. 150; Adv. 58
  electric, Adv. inside front cover, 61, 86, 255, 257, 294, back cover
Copper and alloys, Adv. 69, 102, 114, 335, 364
Counters, Edit. 272; Adv. 68, 355
Couplings, shaft, Edit. 232; Adv. 49, 292, 338, 353
Cylinders, hydraulic, Adv. 8, 89, 95, 248
  pneumatic, Adv. 8, 83, 89, 95, 354

D

Drafting equipment, Edit. 164, 290; Adv. 44, 309, 350, 357
Drilling, Adv. 100
Drives, adjustable speed, Edit. 244, 256; Adv. 58, inside back cover

E

Ejection sets, Adv. 83
Electric equipment (see specific type)
Electronic components advance process methods, Edit. 24
Electronic devices, new, Edit. 28
Engineering department (see Management or Drafting)
Engines, Edit. 37, 204; Adv. 23, 243
Extrusion, Adv. 52, 327

F

Facilities, general, Adv. 26, 97
Facsimile printer combines optics and electronics, Edit. 172
Fasteners, blind, Edit. 150; Adv. 121, 129
  bolts, nuts, screws, Edit. 150, 228, 232, 239; Adv. 6, 26, 30, 35, 71, 75, 79, 90, 110, 121, 126, 240, 256, 265, 316, 318, 320, 326
  insert, Adv. 129, 320
  locking, Adv. 265, 320, 348
  pin, Edit. 256; Adv. 352, 355
  retaining rings, Adv. 19, 329
  rivet, Adv. 30, 129
Feeders, parts, Adv. 260
Felt, Adv. 112, 270, 334
Fiber, Adv. 323
Filters, Edit. 278, 287; Adv. 27, 106, 347, 353
Fitting, capillary tube, Edit. 256
Fittings, pipe, tube and hose, Edit. 282; Adv. 67, 278, 279, 362
Fixtures, Adv. 321
Forging, Adv. 25, 76, 114, 319, 327
Friction materials, Adv. 250, 288

G

Gages, pressure, etc. (see also instruments)
Gas turbine tested for landing craft, Edit 21
Gasket materials, Adv. 267
Gaskets, Adv. 59, 88
Gearing, precision, Edit. 174
Gears, Edit. 160, 174, 230, 232; Adv. 31, 36, 64, 78, 84, 105, 115, 263, 298, 331, 348, 352
Germanium rectifiers, Edit. 211
Glass fiber, Adv. 140
Grinders, Adv. 308
Grommets, Edit. 232
Gyroscopes, Adv. 266

H

Heaters, Adv. 27
Heat exchangers Adv. 40, 120

(*Concluded on page* 10)

one answer... HANNA for all three...

The Hanna name is your assurance of quality. It is backed by over 50 years of specialization on cylinders and control valves. It means economical cylinder power, dependable engineering help and prompt delivery. See your Classified Directory or your Hanna Catalog for the name of your local representative. He is ready to help you solve your power motion problems. Call him today!

Send for your FREE copies of these valuable Hanna Catalogs:

No. 236	Hanna Low Pressure Cylinders
No. 233A	Hanna High Pressure Cylinders
No. 750	Hanna Medium Pressure Cylinders
No. 254	Hanna Control Valves

labor-saving cylinder power

Standard Hanna Cylinders— Matched to the Job!

A choice of hydraulic and pneumatic cylinders to match your power and mounting requirements . . . to improve control and operation of machines and equipment . . . to replace or reduce manual operations. Hanna Valves provide hand, foot, cam or pushbutton actuation; manual, semi-automatic, full automatic or remote control operation.

money-saving engineering

Nation-wide, on-the-spot Sales and Engineering Service!

Hanna experts in cylinder power applications are always ready to help you select the best cylinder and valve combination for your special requirements, to see that you get the most value from your cylinder dollar.

time-saving delivery service

Planned Production Scheduling Assures Prompt Delivery!

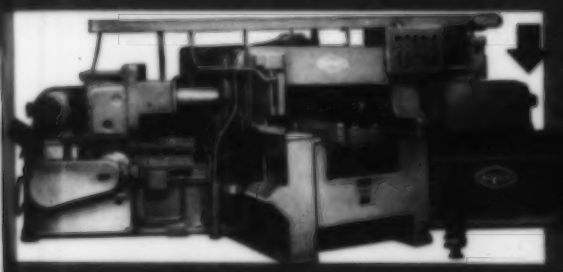
Hanna Sales Representatives located in principal cities throughout the U.S. and Canada can give you **less than three weeks' delivery** on Hanna Cylinders. They carry a stock of Hanna Valves for immediate delivery.

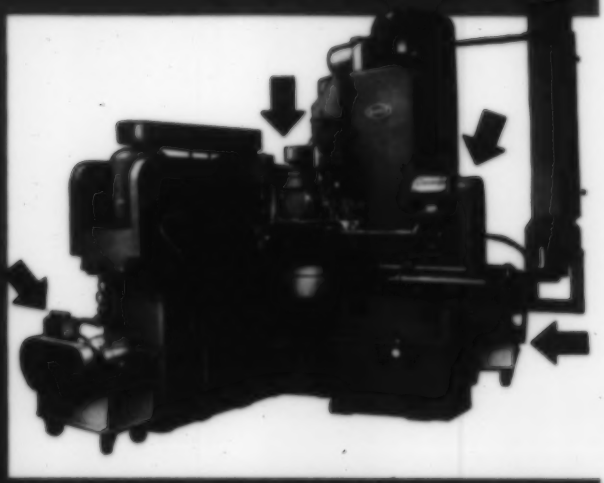
Hanna Engineering Works

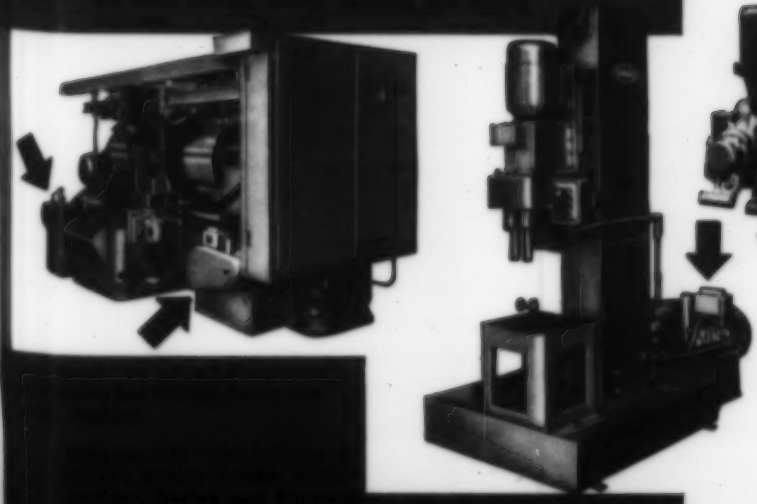
1751 ELSTON AVE. • CHICAGO 22, ILL.

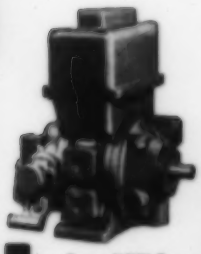
OILGEAR "JK" FLUID POWER FEED PUMPS

AS APPLIED TO BAKER BROTHERS MACHINES









Type "JK" Pump Built in four sizes.

HOW CAN YOU USE THESE SIMPLE, VERSATILE, EASILY APPLIED, PROFITABLE UNITS?

Baker Brothers, Inc., pioneers in machine building, users of Oilgear Feed Pumps since 1925, employ Oilgear "JK" Fluid Power Variable Delivery Feed Pumps on a host of machines including the headline-making 100-foot-long transfer machine and their own commercially available portable hydraulic power unit which you can see in photos Nos. 1 and 3 on this page.

The Oilgear "JK" Feed Pump offers many advantages, not the least of which are easy applicability and accessibility. There's no need in many cases for machine redesign and engineering. And this unit does so much to speed cycle time—traverse speed for example can be 265 times feed rate—that production rises dramatically and costs subside. Both coarse and fine feed rates can be varied infinitely so you at once discover the best rates for your work—and the automatic built-in compensator holds the selected fine feed *unvaryingly*. All functions are controlled automatically, semi-automatically or manually.

Evidence of Oilgear "JK" dependability is growing. In one large automotive plant, now 75% changed over to Oilgear, hydraulic maintenance staff was cut from 6 men to one man per shift. In another great automotive plant, the records show Oilgear is found to give the finest service of all.

There's much more to tell especially about two new units added to the "JK" line. Why don't you send for free literature that gives all the facts and figures. So you won't forget, send for it now.

THE OILGEAR COMPANY
1568 W. PIERCE STREET
MILWAUKEE 4, WIS.

OILGEAR
Fluid Power

PIONEERS . . . NOW THREE PLANTS FOR FLUID POWER

PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS AND VALVES

INDEX

(*Concluded from Page 7*)

Hose, metallic, Adv. 13, 278, 354
Hydraulic equipment (see also specific type)
Hydrostatic lubrication, Edit. 189

I, K

Inspection, Edit. 332; Adv. 353
Instruments, Adv. 266, 353
Knurling, Edit. 181

L

Latches, Adv. 351
Lubricants, Edit. 216; Adv. 310
Lubrication equipment, Edit. 45, 236, 249; Adv. 219, 229, 236, 290, 353
Lubrication, hydrostatic, Edit. 189

M

Machines, special, designing, Edit. 144
Magnesium and alloys, Adv. 114
Magnetos, Adv. 355
Materials handling, Edit. 326
Mechanisms, computer, Edit. 213
Meetings, Edit. 42, 49
Metals (see specific type)
Metals, Edit. 39; Adv. 297
Metals, unit weights, Edit. 205
Metalworking, Edit. 326
Meter, flow, Edit. 151
Motor, outboard, powers industrial truck, Edit. 204
Motor, spring, two-way, Edit. 316
Motors, electric:
- brakemotors, Adv. 300
- fractional and integral hp, Edit. 152, 254, 274, 279; Adv. 1, 46, 80, 86, 91, 103, 113, 227, 312, 328, 337, 345
- gearmotors, Adv. 261
- subfractional, Adv. 351

Motors, hydraulic, Adv. 134, 245
pneumatic, Adv. 85, 272
Mounting, vibration and shock, Edit. 234; Adv. 77, 274, 306, 338

N, P

Nameplates, Adv. 56
Packings, Adv. 59, 288
Particles, solid, in oil, Edit. 216
Pipe, Edit. 282; Adv. 22
Plastics, Edit. 269; Adv. 107, 111, 276, 358
Plastics, impact thermosetting, Edit. 208
Plastics molding, Adv. 99
Plating chromium, Edit. 161
Pneumatic equipment (see specific type)
Powder metallurgy, Edit. 160; Adv. 17, 48, 130, 287
Processing, Edit. 330
Pumps, Edit. 270, 316; Adv. 85, 109, 234, 272, 314
- hydraulic, Edit. 230; Adv. 9, 20, 43, 70, 96, 134, 314

R

Ram jet engine rides helicopter rotor, Edit. 24
Reactor, small, to be designed and built, Edit. 43
Rectifiers, germanium, Edit. 211
Reducers, speed, Edit. 228; Adv. 36, 38, 45, 64, 78, 261
Regulators, flow, Edit. 322; Adv. 307, 353
Relays, Edit. 230, 234, 270, 274; Adv. 249, 257, 294
Rocker arms, stamped, ball-pivot, Edit. 149
Rubber, Adv. 259, 267, 360
Rubber molding, Edit. 259; Adv. 59, 340, 344

S

Screws, ball bearing, Adv. 304
Seals, Edit 246, 322; Adv. 2, 59, 116, 139, 267, 303
- mechanical, Adv. 37, 225, 314

Servos, Edit. 254
Shafts, flexible, Adv. 29, 242, 350
Shapes, special, Adv. 132
Sheaves, Adv. 86, 355
Shock absorber, fluid, Edit. 318
Silicones, Adv. 339
Solenoids, Adv. 294, 352
Special machines, designing, Edit. 144
Spring, plastic, Edit. 316
Springs, Adv. 141, 262
Sprockets, Adv. 66, 98, 128, 247
Starters, motor, Adv. 61, 86, 257, 294
Starting, electric, for power mower, Edit. 188
Steel, Adv. 52, 233, 244, 264, 273, 275
Steel, stainless, Adv. 118, 138, 271, 301, 324
Structures, integrally stiffened, Edit. 197
Switches, Edit. 242, 259, 280; Adv. 28, 104, 127, 257, 294, 298, 356
Swivel joints, Edit. 252; Adv. 254
Systems, hydraulic, Adv. 5, 20, 67, 245

T

Terminals, Adv. 257, 350
Testing, Edit. 332
Thermometers, Edit. 290; Adv. 94
Thermostats, Edit. 246, 279, 284; Adv. 94, 283
Timers, Adv. 28, 231, 249, 257
Torque converters, Adv. 252
Transformers, Adv. 255, 286, 352
Transmissions, variable speed, Adv. 58, 306
Tubing, Edit. 165; Adv. 22, 60, 82, 253, 282, 342
Turbine, gas, tested for landing craft, Edit. 21

U, V

Universal joints, Edit. 242; Adv. 124, 137
Valves, Edit. 228, 230; Adv. 133, 142, 299, 351, 354
- air operated, Edit. 260
- hydraulic, Edit. 228; Adv. 8, 42, 133, 142, 245, 299, 352
- pneumatic, Edit. 228, 282; Adv. 8, 142, 299, 352
- relief, Edit. 266

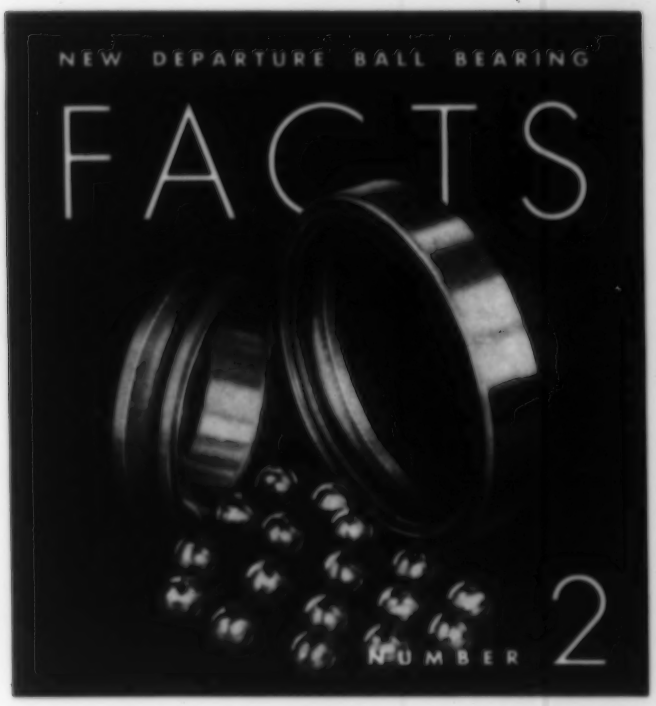
W

Water cooler and heater, Edit. 171
Wear resistant alloys, Adv. 31, 136, 293, 333
Welding, Edit. 218; Adv. 50, 97, 237
Weldments, Adv. 348
Wheels, Adv. 354
Wire and wire products, Adv. 296
Worm drive, ball bearing, Edit. 320
Worm gear jacks, Adv. 39

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

END MAINTENANCE PROBLEMS

with Bearings "Built to Be Forgotten!"



When machine design calls for bearings in inaccessible places, serious maintenance problems often arise. Disassembly for bearing replacement or adjustment is usually costly in both man-hours and lost production. Much the same holds true for many consumer products that must take use and abuse, yet operate efficiently over long periods.

BALL BEARINGS THE SOLUTION

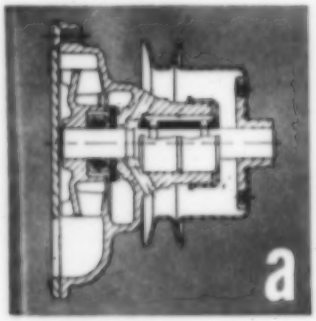
Fortunately, the engineer today has a ready answer at hand. Because of certain unique advantages, ball bearings are ideal in virtually all cases. Ball bearings are permanent, fixed units. When properly enclosed they operate over extremely long periods with practically no wear. Thus, the various parts of the bearing retain their accurate interrelationship. In effect, this means that ball bearings are the most practical of all anti-friction bearings to fit with permanent seals. Lubricant can be enclosed for lifetime operation in many services.

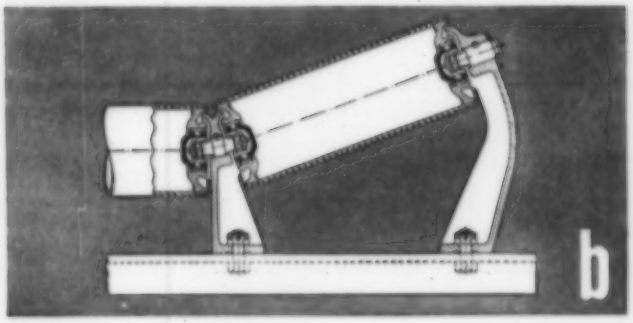
THE SEALED-FOR-LIFE BEARING

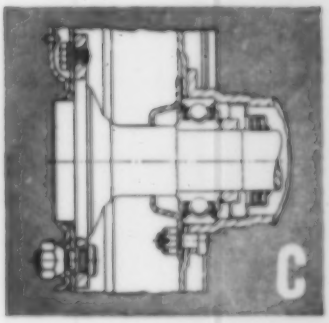
The most logical choice in applications such as those outlined is New Departure Sealed-for-Life bearings. This great advance in bearing design was originated and developed by New Departure. More than 266 million of these bearings have proved their value in service.

In case after case, New Departure Sealed-for-Life bearings have cut maintenance costs to the zero point. Truly, they are *"built to be forgotten"!*

Consult with New Departure on your bearing problems. You will find the experience gained through more than 50 years of designing, testing and manufacturing bearings a major assistance.







A. The automotive fan and pump shaft bearing originated by New Departure demonstrates advantages of the sealed-for-life principle. This bearing has eliminated all the old water pump troubles and service. It requires no relubrication or adjustment. It has proved that it is "built to be forgotten," through use in cars and trucks everywhere.

B. Conveyor roll units constructed around New Departure conveyor bearings require remarkably few parts. Bearings are sealed and lubricated for life. Savings in labor and lubricant are most pronounced. Units with these bearings are economical to produce and easy for the operator to set up. They also are "built to be forgotten."

C. The New Departure rear wheel bearing has made it possible for the engineer to design the simplest, strongest and most foolproof of mountings. This permanently sealed bearing requires no adjustment or relubrication. Grease gun fittings are eliminated. It is famous because it has demonstrated in millions of rear wheels that it needs no attention . . . it can be forgotten.

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

Send for Booklet D-1 on sealed ball bearings

NEW DEPARTURE
BALL BEARINGS
NOTHING ROLLS LIKE A BALL

Engineering News Roundup

Cities Battle for Engineers' Headquarters

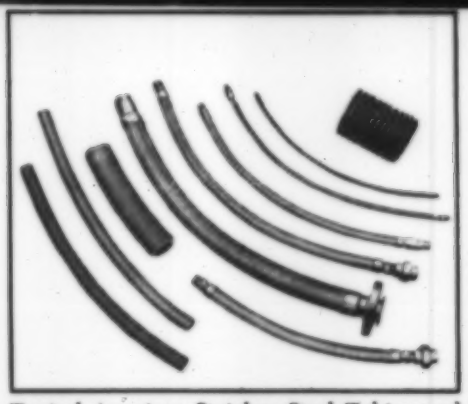
A battle between five cities appears to be shaping up over the location of the new national headquarters of the nation's engineering societies. Chicago industrialists have launched a major campaign to move the society headquarters to their city. New York, on the other hand, has a group of equally determined civic and industrial leaders trying to convince the engineers to stay. Philadelphia, Pittsburgh and Washington, D. C., are strong contenders.

Presently inadequate headquarters of the five founder societies in New York is the spark that touched off the fight. The five societies are the American Society of Civil Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, and the American Society of Chemical Engineers.

Hoover Backs New York: One advantage of the New York location, according to the New York group, is that over 31 per cent of the nation's engineers are located within 200 miles of the city; nearly twice as many, they say, as located within 200 miles of Chicago. Strong backing is given the New York group by former president Herbert Hoover. Hoover is quoted as saying, "I have long held that New York is the only city where the engineers can find a proper intellectual climate, and the most facile association with the industrial and commercial groups with which they have so much to do."

Among the efforts of the New York group to convince the engineers to stay in their city is an offer by a group of industrialists to raise money for a new site in the city. Land on the corner of 60th

QUICK STARTS for jet aircraft engines can be obtained with this new gas-turbine ground power unit. Made by Solar Aircraft Co., the unit can supply 28 volts at 1100 amperes for 2 minutes or 700 amperes maximum continuous. Unique feature of the turbine-generator set is that it can deliver maximum output within 15 seconds after starting at temperatures between −65 to 130 F

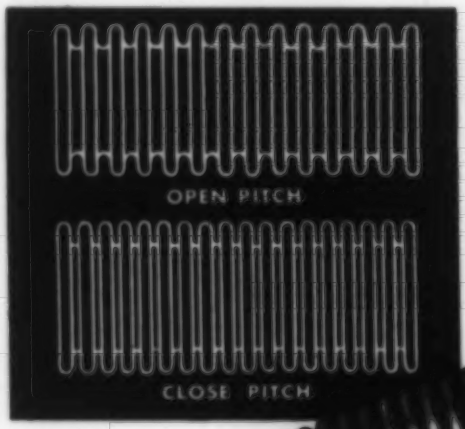


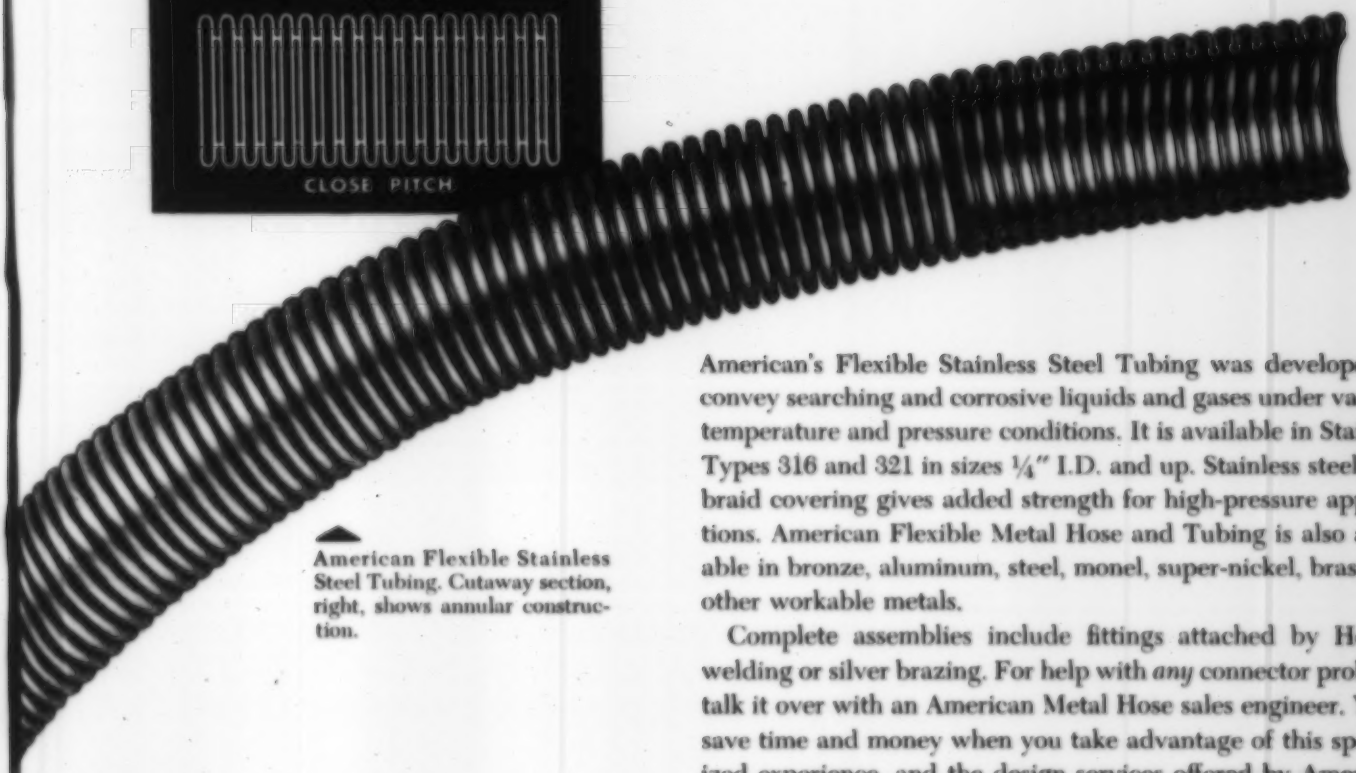
Typical American Stainless Steel Tubing and assemblies designed and manufactured for specific service conditions.

To convey high-temperature, high-pressure CORROSIVE gases and liquids... AMERICAN'S

FLEXIBLE STAINLESS STEEL TUBING

stands up under continuous flexing
absorbs severe vibration
compensates for misalignment
is easily installed



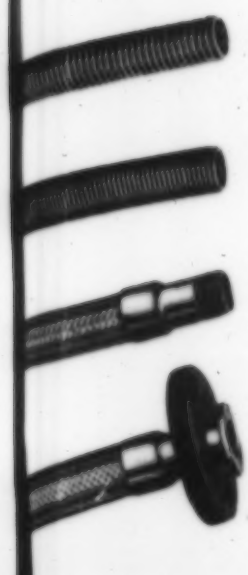


American Flexible Stainless Steel Tubing. Cutaway section, right, shows annular construction.

American's Flexible Stainless Steel Tubing was developed to convey searching and corrosive liquids and gases under varying temperature and pressure conditions. It is available in Stainless Types 316 and 321 in sizes ¼" I.D. and up. Stainless steel wire braid covering gives added strength for high-pressure applications. American Flexible Metal Hose and Tubing is also available in bronze, aluminum, steel, monel, super-nickel, brass and other workable metals.

Complete assemblies include fittings attached by Heliarc welding or silver brazing. For help with *any* connector problem, talk it over with an American Metal Hose sales engineer. You'll save time and money when you take advantage of this specialized experience, and the design services offered by American.

55177



OPEN PITCH for general service

CLOSE PITCH for extra flexibility, frequent movement, excessive vibration

STAINLESS STEEL BRAID gives added strength for high-pressure service

ASSEMBLIES made up to your specifications complete with fittings attached

WHEREVER CONNECTORS MUST MOVE

AMERICAN FLEXIBLE METAL HOSE AND TUBING

AN ANACONDA® PRODUCT

FREE FOLDER!

Four-page folder gives engineering data on construction and types. Includes pressure ranges, bending diameters, weights, data on fittings.

Write today for your copy. Please print.

BD

The American Brass Company, American Metal Hose Branch, Waterbury 20, Connnecticut.

Please send me a copy of Bulletin STC-1, "Flexible Stainless Steel Tubing by American."

NAME.....

COMPANY.....

STREET.....

CITY.....ZONE.....STATE.....

Street and Columbus Ave. has been promised available by the New York Committee on Slum Clearance.

Chicago Pledges Cash: Chicago has gone all out in their campaign to win the engineers. A profusely illustrated 23-page booklet provides the initial ammunition. Loaded with facts and figures, the brochure gives several major reasons why Chicago is the ideal site. Among these are the central location, good transportation, services of the world's best known technological library, availability of a choice 5-acre site, and an almost $2.5 million saving in construction costs.

The site, on the Illinois Tech Campus, is free, according to the Chicago committee. Thus, existing parking and heating facilities, conference and meeting rooms, and eating facilities would be available. Other sites have also been announced available to the societies without charge.

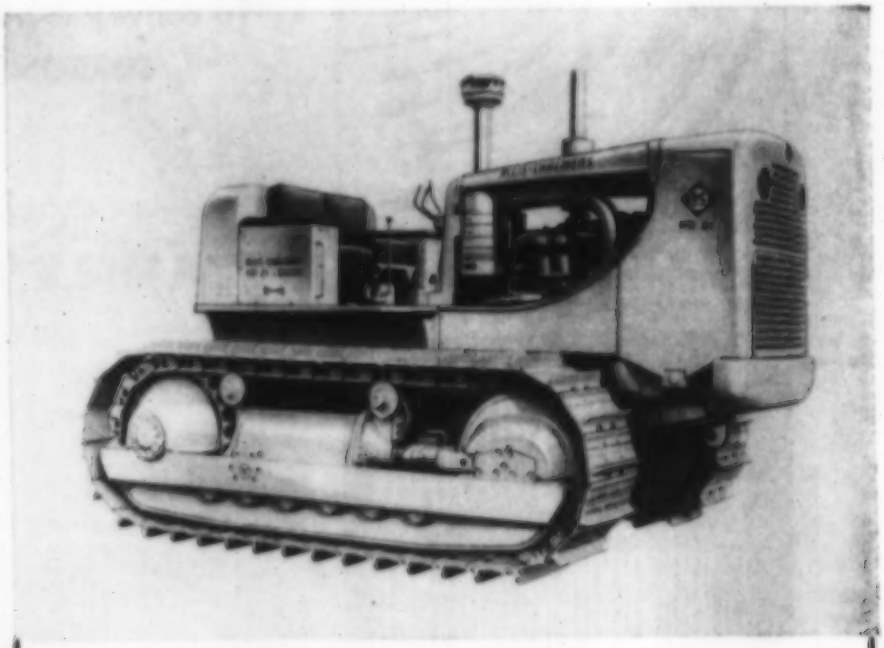
Hard cash further backs the Chicago Plan. Over $200,000 has already been pledged by a small number of Chicago companies. More is expected as time goes on.

Committee Picks Pittsburgh: Latest development in the affair is a recommendation by a committee of past presidents of the five societies to locate in Pittsburgh. This recommendation was presented to the AIEE Board of Directors recently. No action was taken, but a special meeting is expected to be called to consider the recommendation. It has been reported that about $1.5 million and a choice of seven free sites have been offered the engineers by a Pittsburgh group. Naturally, spirited civic interest evidenced by this offer may go a long way toward influencing a decision. Another factor influencing the decision was reported to be the fact that over 50 per cent of the country's engineers, are said to live within 400 miles of Pittsburgh.

Philadelphia interests are rumored to have pledged somewhere near $400,000 so far toward the establishment of the engineers' headquarters in the Quaker City.

New Corporation Urged: United Engineering Trustees, the founder societies' holding company, has been reported favoring the New York site. Liquidation of this group has been urged by the past presidents committee so that a new corporation may be formed to build, operate and maintain a new engineering center.

Boards of Directors of all five societies are expected to meet in the near future to consider the various proposals. A majority of the five Boards favoring a particular location is needed before the move can be made. A final decision is not expected for several months.



POWERFUL CRAWLER being made by Allis-Chalmers is said to be the largest and most powerful tractor ever put into production. Weighing 22 tons, the tractor is rated at 204 hp. A newly designed high-output torque converter, a new high-capacity cooling system and a new diesel engine are said to add up to give the extra performance. New heat treating methods permit achieving optimum track hardness, according to Allis-Chalmers

Machine-Tool Design Competition Announced

The James F. Lincoln Arc Welding Foundation has announced a $12,000 Machine Tool Design Award Program. Awards will be made for papers describing the use of arc welding as applied to machine tool design.

The program is open to all persons who are or have been engaged in the design or making of metal-cutting or metal-forming machine tools. A total of 15 awards will be made with a top award of $3,000. Awards will be made to the 15 best papers submitted describing the use of arc welding in the design of a component part or complete machine tool. Work or equipment described must have been planned or executed during the period January 1, 1953 to July 15, 1955. Details of the program may be obtained from the James F. Lincoln Arc Welding Foundation, Cleveland 17, Ohio.

Clarostat Mfg. Co. has announced its acquisition of Campbell Industries Inc. of Chattanooga. Campbell manufactures highly specialized carbon resistor products and will supplement the Clarostat line.

connections simplified

Rounding Up the 1955 Automobiles—3

In winding up the 1955 automobiles this month, the new Packard seems to attract the most attention engineering-wise. Besides a newly designed Twin-Ultramatic transmission, Packard features a torsion-bar suspension, which eliminates the front-coil and rear-leaf springs. An electric-motor drive automatically compensates for variations in loading. Chrysler has introduced its Imperial as a separate new line in the luxury class. Nash features a new wrap-around windshield and a new engine. Hudson has adopted the Nash body shell and construction features. Cadillac features an improved V-8 engine and a wide selection of exterior and interior color options. Willys have been restyled inside and out.

Willys

Willys passenger cars have been restyled with a new full-width grill that improves engine cooling. Chrome molding and newly designed bumpers give the car a fresh 1955 appearance. Wheelbase remains the same, but overall length has been increased by 7 inches. Easier steering is provided by a new worm and roller steering system. Willys overlapping windshield-wiper action has been retained this year. Hydra-Matic transmission is again available as an option. Tubeless tires are standard on all models.

Engine Specifications

	Custom and Bermuda	Station Wagon
Type	L-head, in-line	F-head, in-line
No. cyls.	6	6
Bore & stroke (in.)	3.31 x 4.375	3.125 x 3.5
Displ. (in.³)	226.2	161
Comp. ratio	7.3 to 1	7.6 to 1
Bhp, max	115 @ 3650	90 @ 4200
Torque, max (lb-ft)	190 @ 1800	135 @ 1600

Size and Weight

	Custom and Bermuda	Station Wagon
Wheelbase (in.)	108	104
Length (in.)	189⅞	176¼
Width (in.)	72	71¾
Height (in.)	60	72
Weight (lb)	2800*	2831*

* Approximate weights.

Packard

Packard for 1955 offers a new torsion-bar suspension, said to improve riding qualities and give greater stability at higher speeds. The new suspension system eliminates the customary front-coil springs and rear-leaf springs. A long solid manganese-steel bar runs on each side of the chassis frame connecting the front and rear wheels by means of arms and links. Spring action is obtained by twisting the bar. A load compensator, consisting of an electric motor and two additional torsion bars, automatically adjusts the suspension for variations in load. Thus, a level ride is always assured. Three new V-8 engines power the 1955 Packards. Packard Four-Hundred and Patrician models are powered by a new 260-hp engine. Clipper Custom models are powered by a new 245-hp engine and Clipper Super and Deluxe models are powered by a 225-hp engine. Newly designed Twin-Ultramatic transmission is standard on all except Clipper models. A total of 53 exterior color combinations are available along with 60 choices of interior treatment.

Engine Specifications

	Clipper	Clipper Custom	Packard
Type	OHV, Vee	OHV, Vee	OHV, Vee
No. cyls.	8	8	8
Bore & stroke (in.)	3⅛ x 3⅛	4 x 3⅛	4 x 3⅛
Displ. (in.³)	320	352	352
Comp. ratio	8.0 to 1	8.5 to 1	8.5 to 1
Bhp, max	225 @ 4600	245 @ 4600	260 @ 4600
Torque, max (lb-ft)	325 @ 2400-2800	355 @ 2400-2800	355 @ 2400-2800

Size and Weight

	Clipper Series	Packard
Wheelbase (in.)	122	127
Length (in.)	214.8	218.5
Width (in.)	78	78
Height (in.)	62	62.3
Weight (lb)	3915*	4355

* Shipping weight for Clipper Custom.

Nash

Nash leads off this year with a V-8 Ambassador as its top line. Powered by a new 208-hp V-8 engine, this new line offers Packard's Twin-Ultramatic transmission as an option. An Ambassador Six and Statesman Six round out the series. A new wrap-around

Engine Specifications

	Statesman	Ambassador	
Type	L-head, in-line	OHV, in-line	OHV, Vee
No. cyls.	6	6	8
Bore & stroke (in.)	3½ x 4¼	3½ x 4⅜	3⅛ x 3½
Displ. (in.³)	195.6	252.6	320
Comp. ratio	7.45 to 1	7.6 to 1	7.8 to 1
Bhp, max	100 @ 3800*	130 @ 3700*	208 @ 4200
Torque, max (lb-ft)	155 @ 1600	220 @ 1600	300 @ 2000-2600

* Increased horsepower available with dual carburetors and high compression head.

NO SIDE LINE

BOUND BROOK'S

MAJOR PRODUCTS ARE

THE WORLD'S FINEST

POWDER METALLURGY

BEARINGS AND PARTS

BOUND BROOK OIL-LESS BEARING CO., BOUND BROOK, N. J.

windshield and restyled front fenders give the car a new look. Headlights have been moved inboard, a feature said to have been inspired by European sports cars. Riding qualities are said to be improved by the addition of a rugged front suspension cross-member assembly which is mounted in rubber to the body sill structure. Air conditioning, reclining seats and the "Twin Travel Bed" are available on all Nash models at extra cost.

Size and Weight

	Statesman	Ambassador
Wheelbase (in.)	114¼	121¼
Length (in.)	202¼	209¼
Width (in.)	78	78
Height (in.)	61⅜	62¼
Weight (lb)	3070*	3480*

* Shipping weight.

Hudson

Hudson has been completely restyled for 1955. Probably as a result of the Nash-Hudson merger, Hudson's distinctive styling has given way to Nash styling. All that remains of the former Hudson series is the name and two 6-cylinder engines. Hudson's Hornet is available with the same 208-hp V-8 as the Nash Ambassador. Here again, Packard's Twin-Ultramatic is available at extra cost. Hornets are also available powered by Hudson's 6-cylinder 160-hp engine which may be stepped up to 170 hp with a high-compression head and dual carburetors. Likewise, the 110-hp six may be stepped up to 120 hp with the same equipment. All Hudson models are available with Nash air conditioning, reclining seats and "Twin Travel Beds" as optional equipment. Hudson bodies are Nash-designed single-unit construction.

Engine Specifications

Type	OHV, Vee	L-head, in-line	L-head, in-line
No. cyls.	8	6	6
Bore & stroke (in.)	3⅛ x 3⅛	3⅛ x 4⅛	3 x 4⅝
Displ. (in.³)	320	308	202
Comp. ratio	7.8 to 1	7.5 to 1	7.5 to 1
Bhp, max	208 @ 4200	160 @ 3800*	110 @ 4000*
Torque, max (lb-ft)	300 @ 2000-2600	264 @ 1800	158 @ 1400

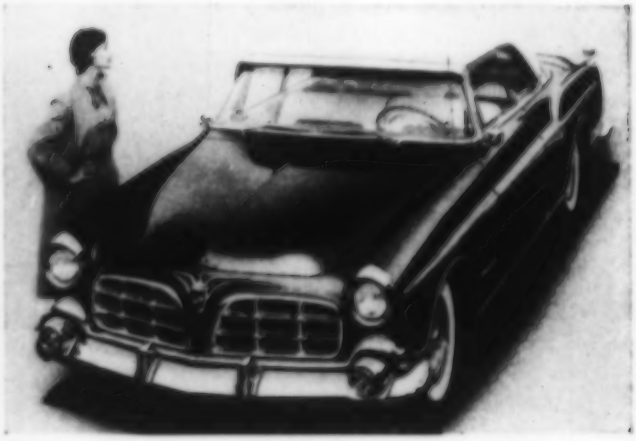
* Increased horsepower available with dual carburetors and high compression head.

Size and Weight

	Hornet	Wasp
Wheelbase (in.)	121¼	114¼
Length (in.)	209¼	202¼
Width (in.)	78	78
Height (in.)	62¼	61⅝
Weight (lb)	3848	3347

Imperial

Imperial is the newcomer this year and is to be a completely new and separate Chrysler line. Although it has its own distinctive styling, it is powered by the Chrysler 250-hp V-8. Wheelbase is the longest of the entire Chrysler line. Tail lights raised above the rear fenders are an identifying feature. Disk brakes are standard equipment on the Crown Imperial, largest of the series. Powerflite transmission is standard, with the control lever on the dash. Coaxial power steering, power brakes, power-operated front seat and air conditioning are all included as regular equipment.



Engine Specifications

Type	OHV, Vee
No. cyls.	8
Bore & stroke (in.)	3.81 x 3.63
Displ. (in.³)	331
Comp. ratio	8.5 to 1
Bhp, max	250 @ 4600
Torque, max (lb-ft)	340 @ 2800

Size and Weight

	Imperial	Crown Imperial
Wheelbase (in.)	130	149.5
Length (in.)	223	243.6
Width (in.)	79.1	79.1
Height (in.)	61.2	62.4
Weight (lb)	4565	4565

Cadillac

Cadillac exterior treatment has been changed somewhat to give the cars a new look for 1955. An improved engine is rated at 250 hp with a 9 to 1 compression ratio. Redesigned valve rocker arms and a newly designed carburetor are among the engineering improvements said to contribute to higher horsepower. Other improvements include a more rigid camshaft, narrower connecting rod bearings made of an improved bearing material, and a new higher capacity water pump that provides more even engine operating temperatures. Shock-absorber valv-

ing has been refined to improve riding characteristics. Road vibration in the steering wheel is said to be virtually eliminated by a newly designed coupling in the steering shaft. Over 500 single and two-toned color combinations can be derived from the basic selection.

Engine Specifications

Type	OHV, Vee
No. cyls.	8
Bore & stroke (in.)	3⅛ x 3⅝
Displ. (in.³)	331
Comp. ratio	9 to 1
Bhp, max	250 @ 4600
Torque, max (lb-ft)	345 @ 2800

Size and Weight

	Series 62*	Series 60	Series 75
Wheelbase (in.)	129	133	149.8
Length (in.)	216.3	227.3	237.1
Width (in.)	80	80	80
Height (in.)	62.1	62.1	63.9
Weight (lb)	4370	4545	5055

* Figures given are for 5-passenger sedan.

Chrysler

Chrysler for 1955 claims a completely redesigned car from bumper to bumper. Longer and lower, the cars are powered by two new V-8 engines. Windshield area has been increased 20 per cent by adopting the wrap-around design. Arrangement of the chrome molding combined with fin-like tail lights give the car that "forward look." One notable change over previous models is the placement of the Powerflite selector lever on the dash. Nylon bushings replace bronze bushings in the brake linkage. A newly designed frame permits the rear springs to be mounted farther apart. Roll on turns is said to be reduced, resulting in a steadier ride. Trunk-lid counterbalance springs have been replaced with a torsion-bar hinge mechanism. Chrysler-designed coaxial power steering (See MACHINE DESIGN, September, 1954, Page 31) is available on all models.

Engine Specifications

	Windsor	New Yorker
Type	OHV, Vee	OHV, Vee
No. cyls.	8	8
Bore & stroke (in.)	3.63 x 3.63	3.81 x 3.63
Displ. (in.³)	301	331
Comp. ratio	8.9 to 1	8.5 to 1
Bhp, max	188 @ 4400	250 @ 4600
Torque, max (lb-ft)	275 @ 2400	340 @ 2800

Size and Weight

	Windsor	New Yorker
Wheelbase (in.)	126.0	126.0
Length (in.)	218.6	218.6
Width (in.)	79.1	79.1
Height (in.)	60.6	60.9
Weight (lb)	...	...

Also Listed

The only change in the Kaiser line for 1955 is the serial numbers; present body styles and engines will be used.

In addition to the models announced in January, Studebaker has recently announced a new "Ultra Vista" sedan and station wagon series for 1955 featuring increased horsepower and wrap-around windshields. A new "Bearcat" V-8 engine to power the restyled Commander series is rated at 162 hp with a compression ratio of 7.5 to 1 and a displacement of 259.2 cubic inches. A four-barrel carburetor kit is available to provide an additional 20 hp. Studebaker's President line boasts a 185-hp V-8 equipped with a four-barrel carburetor. Compression ratio is 7.5 to 1 with an 8 to 1 ratio optional. These new engines, it was announced, will be standard on all Studebaker Commander and President models.

Gas Turbine Tested For Navy Landing Craft Use

Results of tests of a small gas turbine engine in a standard Navy LCVP indicate that the engine is capable of performing many tasks required in Navy fleet operations.

Endurance tests of the turbine were conducted to determine its reliability. According to the Navy report, there was no failure of the gas turbine drive during the ten 5-hour tests. A final inspection revealed no damage to the components, nor did any parts require replacement.

An advantage of the gas turbine in this type of operation is its high initial shaft torque which applies greater force if the propeller becomes imbedded in sand during beaching operations. The chief disadvantage is that the turbine-powered craft uses more than twice as much fuel as a conventional diesel-powered LCVP.

However, the gas turbine gives vibration-free operation, resulting in less wear on parts. It is easy to install and can be taken apart and reassembled in 6 hours. No warm-up time is necessary and full power can be applied immediately after starting. In contrast to other types of engines, tests show that the colder the weather, the more power is available. Stalling the engine by

(*Continued on Page* 24)

Sanitation's A Cinch with *Carpenter* Stainless Tubing for Parts or Process Lines

For example: The filler tubes for ½ gallon milk bottles must be of such a quality that the manufacturer can polish both I.D. and O.D. to the equivalent of a sanitary finish. That's why he specifies Carpenter Stainless Tubing.

Carpenter Stainless Is First Choice For:

Finish There are never any pits, checks or scratches when you buy polished Carpenter Stainless Tubing.

Strength Tight adherence to specifications for physicals is a Carpenter specialty.

Light Weight Because the analysis is exact—the wall within specifications—the dimensions, too. Carpenter weights are on-the-button.

Ductility Carpenter Stainless is easy to fabricate because tempers are "as specified".

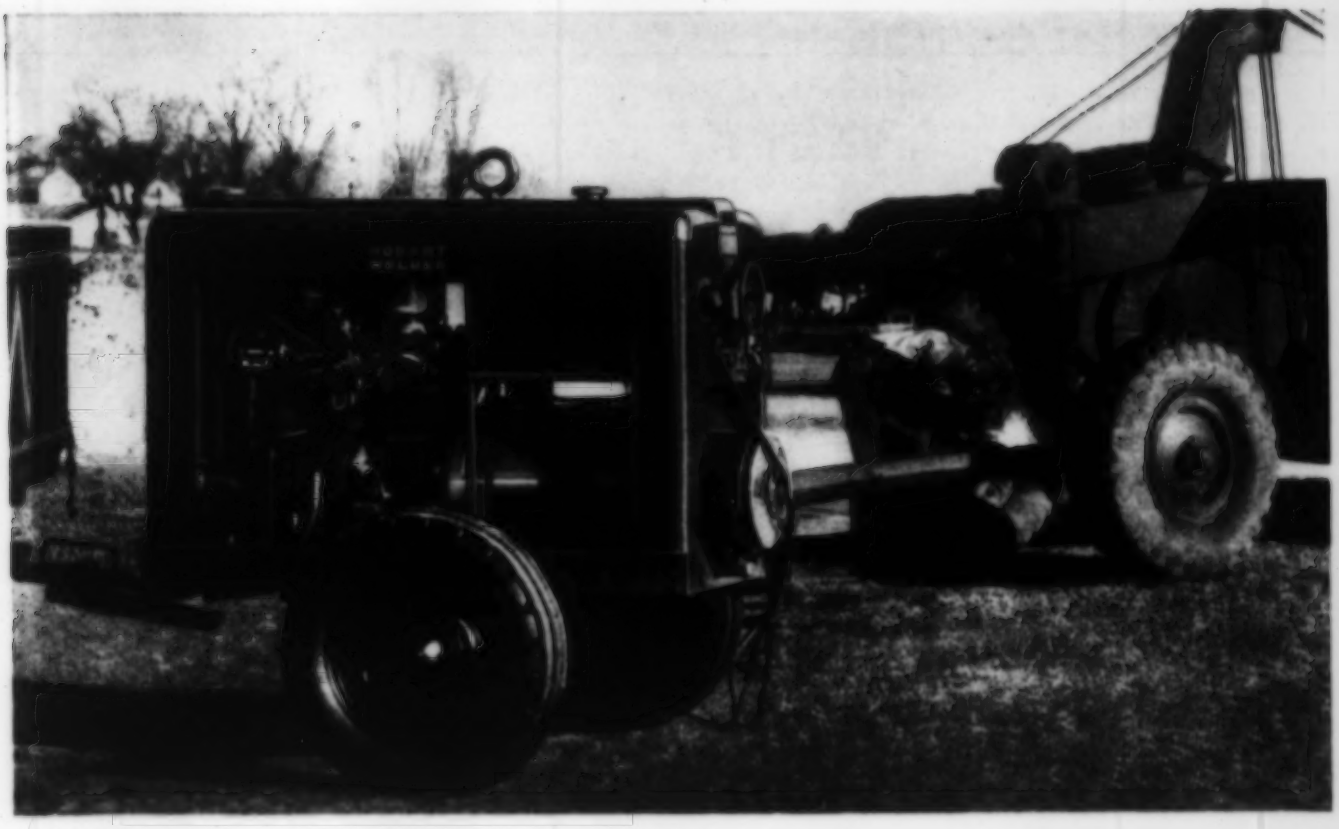
Uniformity Carpenter customers depend on the uniformity of Carpenter quality—length-to-length, order-to-order.

Availability There is a Carpenter Distributor with adequate warehouse stocks as close as your telephone. He is ready, willing and able to give you any engineering or design help you need. When you call Carpenter, "One Call Does It All".

The Carpenter Steel Company, Alloy Tube Division, Union, N. J.
Export Dept: The Carpenter Steel Co., Port Washington, N. Y., "CARSTEELCO"

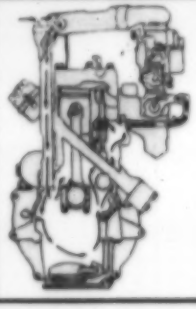
New Technical Bulletin on Fabrication Data for Carpenter Stainless Tubing and Pipe now available. Send for free copy.

Carpenter
Stainless Tubing & Pipe



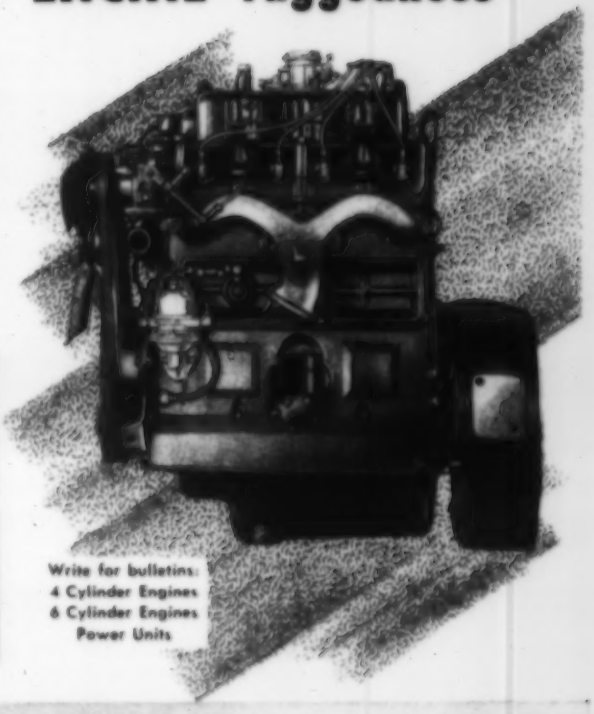
*Hobart Welder with JEEP ENGINE ruggedness

From the proven design of the perfected "Jeep" Engine has come four tough, 4 and 6 cylinder POWER GIANT Industrial Engines. Here's new low Engine maintenance . . . new high Engine dependability . . . whether installed directly into your equipment or employed in the Willys Power Unit. For technical information on Willys rugged designs and their "proven-in-action" features, write today.



POSITIVE
crankcase ventilation

Willys positive ventilation is **automatically regulated to engine speed.** Filtered air forces removal of oil-thining or acid-forming condensates. It is one of many Willys "proven-in-action" features for rugged power uses.



Write for bulletins:
4 Cylinder Engines
6 Cylinder Engines
Power Units

Willys

POWER GIANT Industrial Engines and Power Units

WILLYS MOTORS, INC. • ***Industrial Engine Department***

1460 NORTH COVE BLVD. TOLEDO, OHIO

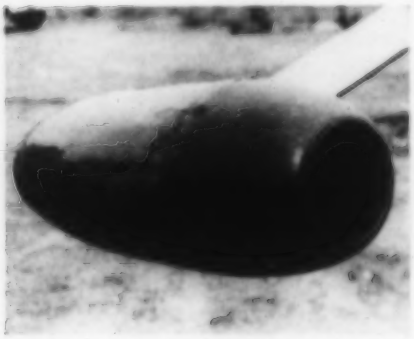
(*Continued from Page* 21)
restraining the propeller is impossible, a great advantage in landing operations.

Ram Jet Engine Rides Helicopter Rotor

Recent CAA certification of a watermelon-size ram jet engine has opened the way for simplified propulsion of helicopters, according to Hiller Helicopters. It is claimed to be the first ram jet engine approved by CAA and the first designed for tip mounting on helicopter rotor blades.

Weighing just over 12 lb, the engine develops 45 hp. No moving parts are used in the engine. It consists of a streamlined "stovepipe" into which fuel is fed at a constant flow. At high speeds, air is rammed into the forward part of the tube, becomes mixed with the fuel and moves back into the combustion chamber. Ignition is accomplished with a spark plug and maintained by flame holders. When the burning and expansion occurs, thrust results from the expulsion of gases at the rear. Additional air being rammed into the front builds up pressure that prevents gases from escaping toward the front of the tube.

Engine life expectancy has not been established. The standard endurance test of 150 hours of operation was said passed with no limitations. Fuel consumption is considerably higher than other types of power plants now in use. This problem, says Hiller, will be alleviated with the development of improved burning devices.



About as big as a medium-sized watermelon, the 45-hp ram jet engine is 21 inches long and has a maximum diameter of 8 inches

Maintenance of this new Hiller ram jet engine is greatly simplified. Changing engines and overhaul time is only a fraction of that required for conventional powerplants

Helicopter performance is expected to be improved by applying the power to the tips of the rotor where most of the lift is generated. Complex torque compensating mechanisms, oil and cooling systems, drive systems and intricate mechanisms of reciprocating engines will be eliminated. As a result, cost of the machines and maintenance is expected to be substantially reduced.

New Components Advance Electronic Process Methods

Two new components developed for use in automatic production of electronic units have been announced by the National Bureau of Standards.

A newly developed adhesive tape capacitor and a "chip" resistor are expected to increase the number of kinds of electronic units that may be manufactured by automatic production methods. These new components have been developed to fulfill the need for special resistors and capacitors capable of being fitted into specially designed wafers. These wafers are, in turn, automatically made into a variety of electronic units.

Formerly caller Project "Tinker-

Previews

Getting a Good Grip

Knurling, used widely for knobs and metal inserts, can be specified on a part by either one of two systems, the older teeth-per-inch method or the diametral pitch system. The article on Page 181 outlines how to use each, and gives practical pointers on knurling specification for easy production.

A Squirt of Oil

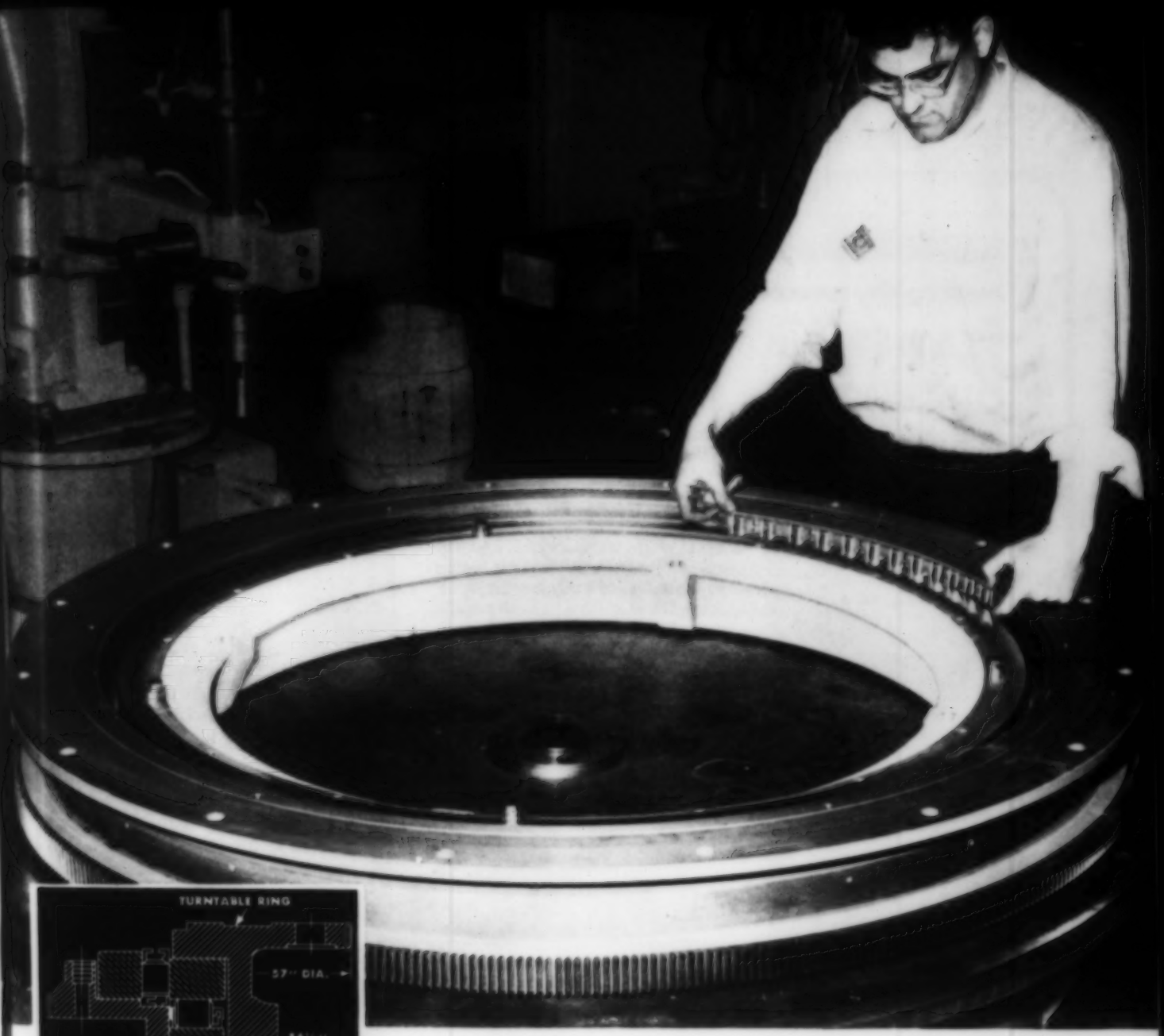
Bearings that almost literally balance the shaft on a squirt of oil are discussed in the article on hydrostatic lubrication on Page 189. Pressurized oil is fed to high-pressure pads in the bearing, floating the whole rotating assembly. Coefficients of friction, and starting and running torques, are phenomenally low—much lower than in any other type of bearing.

Thick and Thin

Most hyperbolic superthuliated widgets, as everyone knows, are driven by midget-sized fractional-horsepower motors. But the application problems involved are not simple. For one thing, a superthuliated widget is a double-dendritic device requiring high lamellar torque, measured on a toroidal Twaddle scale. And this low reluctant input, combined with the need for a repulsion-start invective motor, really breeds design headaches. We don't recommend Fred Olson's article in this issue for answering the knotty motor-application problems of the superthuliated widget. But if you want to read a *sensible* discussion about fractional-horsepower motors, you might turn to Page 152.

Midgets for Widgets

Chrome plating can be applied as thin as 0.00001-inch for some applications—mainly decorative. But for others, thicknesses may range up to hundredths or even tenths of inches. Where to use which thickness depends on the expected service factors. The article on Page 161 by J. B. Mohler outlines proper thicknesses for functional uses ranging from chrome plating for appearance to heavy-duty wear resistance.



Switch to SSW forged rings in bearing assembly adds to "ultra-accuracy" of naval gun director

Three forged rings which are the major parts of this bearing assembly for a naval gun director contribute to required "ultra-accuracy." By switching to Standard Steel forgings in two of these rings General Electric Company, Pittsfield, Mass., gets *all* these benefits.

1. The 57-in. O.D. turntable forged ring (formerly a casting), improves uniformity and stability of the metal, its machinability, and reduces required machining.
2. Proper heat treatment and precision machining give extreme smooth rotation on the roller bearings and accurate positioning without backlash.
3. Production has been simplified and speeded up and fabrication costs reduced.
4. The stationary 50-in. O.D. inner ring eliminated a weldment consisting of five rings cut from steel plate.
5. These rings cost less than cast rings in the quantities needed.

You, like General Electric, will benefit by using Standard Steel Works forgings. It'll be to your advantage to check how profitably SSW forged rings can replace weldments and castings. Why not write today for more information? Please address Dept. 8764, Standard Steel Works Division, Baldwin-Lima-Hamilton Corp., Burnham, Pennsylvania.

BALDWIN BLH LIMA-HAMILTON

Standard Steel Works Division
Burnham (Mifflin County), Pa.

BALDWIN-LIMA-HAMILTON
General Offices: Philadelphia 42, Pa. • Offices in Principal Cities

Parts machined by Non-Gran under

STATISTICAL QUALITY CONTROL...

bring important new freedom to design

Real tolerance limits become known and practical limits can be set with assurance when parts are machined at Non-Gran under statistical quality control methods. Learn what this can mean to your product. Write, or wire, your requirements—with prints and "specs" to follow.

AMERICAN NON-GRAN BRONZE COMPANY

Berwyn, Penna.

METROPOLITAN PHILA., ON THE PENNSYLVANIA R. R. MAIN LINE.

here's what **DIE CAST**

GRC ZINC ALLOY THREADED

FASTENINGS

mean to you...

in terms of a better product in terms of a more economical product!

Every Quality Feature is an Economy Feature!

- The plain bright finish does not require further surface finishing for most applications
- Closer tolerances • Cleaner threads • Greater dependability, durability • Die-cast uniformity
- LOWER PRICED!
- NON-FERROUS • RUST-PROOF
- CORROSION-RESISTANT

Quick deliveries from stock • Specials to order
Write today for samples, prices & bulletins

GRIES REPRODUCER CORP.

32 Second St., New Rochelle, N. Y. • NEw Rochelle 3-8800

World's Foremost Producer of Small Die Castings

News Roundup

toy," the automatic production process takes raw or semiprocessed materials and manufactures bases, dielectric elements for capacitors, and tape for resistors. Machinery used in the process prints the conducting circuits and mounts all the capacitors and resistors on special ceramic wafers. All the wafers are then automatically stacked into modules. Each module performs the functions of one or more electronic stages such as may be used in computers, instrument amplifiers, servo amplifiers or even radio or television equipment.

Adhesive tape capacitors made for automatic processing consist of a printed silver pattern and a piece of conducting adhesive tape. The silver pattern forms one electrode of the capacitor and is printed and fired on the ceramic wafer. The adhesive tape that forms the other electrode is dielectric coated. After being cut into pieces of the proper size, the tape is laid over the silver pattern, then oven cured. Capacitors of various sizes are made by varying the size of the pattern and the thickness of the dielectric coating.

The "chip" resistors are made by applying adhesive resistor tape to a rectangular ceramic chip. Tinned and silvered connecting tabs are fired onto each end of the chip before applying the resistive tape. A roll of tape of the proper resistance is fed into a machine that cuts and presses the tape on the chip, overlapping the metallized tabs on each end. When all this is completed, the resistor is automatically fed into an oven and cured.

One such commercially made resistor is ½-inch long and about 0.15-inch wide. Made by Hansen Electronics Co., the units are available in resistances from 39 ohms to 4.7 megohms, and were designed especially for experimental work in printed circuits. About 1/64-inch thick, these resistors are said to be capable of operation to 200 C.

One of the chief advantages of chip resistors to designers working with printed circuits is that different resistance values can be tried without the necessity of curing a complete circuit. Generally, the resistors are printed on the wafer along with the other conductors.

TWO Profitable Ways to use FRANTZ

FERROFILTER

Magnetic Separators

Pipe Size 1" and smaller

Pipe Size 1½" and larger

1 Keep coolants free from chips and other small ferrous particles such as rust and scale on critical operations like tapping and threading, deep drilling and reaming, trepanning and gear cutting. Removal of magnetic particles contribute to longer tool life, more production between grinds and finer precision finishes.

2 Keep lubricating oil and hydraulic fluids free from minute ferrous particles and metal worn off working parts, as well as scale and rust. You'll reduce damage to pumps, bearings and gears; cut down costly maintenance and repairs.

Send for BULLETIN PM-83 with complete information on how Ferrofilters are made and operate; on sizes available, dimensions and capacities.

S. G. FRANTZ CO., Inc.

P. O. Box 1138 Trenton 6, N. J.

Changing values of printed components is impossible without making up a complete circuit on another wafer.

Solution Found For Engineer Shortage?

A shortage of technically trained American women is one of the reasons why the United States is losing its scientific manpower advantage to the Soviet Union, according to Dr. John T. Rettaliata, president of Illinois Institute of Technology.

"Any woman possessing reasonable intelligence and a liking for the work can master the training, do the job, and not lose the identity of her sex in the process," Dr. Rettaliata maintains.

Education of women in engineering has progressed at a snail's pace here, he said. In Russia an estimated 25 per cent of the engineers are women, while in the U. S., less than one per cent of the approximately 500,000 engineers are women. Although the number of Russian engineers of both sexes is estimated at about 100,000 fewer than the American total, during the last four years the Soviet Union has graduated about 154,000 engineers compared with only 116,000 in the U. S. Last year's engineering graduates from American colleges were only 20,000, against 54,000 for the Russian institutions.

"No sooner do I get a new machine designed than some clown dreams up another innovation."

Industry's Most Versatile Heat Source

CHROMALOX *Electric* Strip Heaters

EASY TO INSTALL Chromalox Strip Heaters give dependable, accurately controlled heat where and when heat is needed. They produce uniform and exact temperatures by automatic or manual controls. Low initial installation and operating costs are among their many advantages. Get details now about Chromalox Heaters for heating liquids, gases, platens, molds, moving parts, etc.

Write for Catalog 50

It describes many Chromalox Electric Heaters and tells how to apply them.

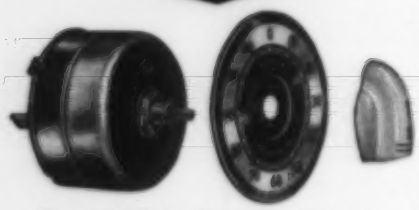
A-4441

Industrial Div., EDWIN L. WIEGAND CO.
7575 Thomas Blvd., Pittsburgh 8, Pa.

CHROMALOX
ELECTRIC HEAT FOR MODERN INDUSTRY

MARK-TIME
"9200"

Bell Signal
Time Switch



Specifications: U/L approved. 30 amp. ½ hp., 120-240 v. AC only. Diameter, 2 1/32"; depth, 2 1/4"; center stud mounting.

Combines
LOW COST
VERSATILITY
SALES APPEAL

The Mark-Time 9200 Bell Signal time switch has been redesigned to increase its already wide acceptance. This switch has proven itself on clothes dryers, ranges, broiler-rotisseries, battery chargers, washing machines, and in many other applications where an automatic time switch and bell signal are needed. It is the most versatile bell signal time switch on the market . . . available in various combinations of circuit arrangements and dial styling, and ideal for all heating elements with high voltage requirements.

The "9200" is a streamlined, durable, low cost unit which normally breaks two circuits simultaneously (DPST), and at the same time sounds a clear, resonant bell signal. It is designed for easy, economical installation on all ranges and other appliances, and is engineered for rugged dependability, accuracy and high quality.

Write today for full details and prices.

MARK-TIME **FIRST where quality counts**

M. H. RHODES, INC.
HARTFORD CONNECTICUT

Manufactured and sold in Canada by
Sperry Gyroscope Ottawa, Ltd., Ottawa, Ont., Canada

Engineers Told of New Electronic Devices

A motorless all-electronic refrigerator and an electronic light amplifier were among the newly developed electronic devices revealed at the recent annual meeting of the American Institute of Electrical Engineers.

Both were developed by the Radio Corp. of America. Described by David Sarnoff, RCA board chairman, the new developments are still in the experimental stage.

A principle known for more than 120 years has been applied in the development of the all-electronic refrigerator. Known as the "Peltier effect," the principle states that the passage of an electric current through two dissimilar metals produces either a heating or cooling effect, depending upon the direction of the current.

Lack of materials capable of producing sufficiently low temperatures prevented the effect from being put to practical use. Recent new studies in solid-state physics provided new information with which to attack the problem.

As a result, this all-electronic refrigerator, capable of producing practical storage and freezing temperatures, was developed. Tiny thermojunctions absorb and remove heat from the cooling compartments when electric current

Electronic light amplifier may eventually replace present TV picture tubes with a flat wafer-type screen

All-electronic refrigerator developed by RCA has no moving parts. It is believed to be the first refrigerator of this type to achieve practical storing and freezing temperatures

FLEXIBLE SHAFT

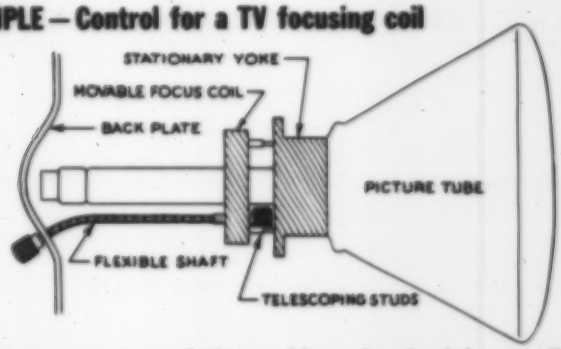
Fact and Fiction

FACT

Alignment problems never enter the picture when you use S. S. White Flexible Shafts.

WHY? Because S.S.White flexible shafts of both the power drive and remote control type have an unusual degree of adaptability. Their flexible construction permits them to be installed and operated around, over or under obstructions with ease. In fact, they offer the one simple, low-cost way to "live with misalignment — and like it"!

EXAMPLE — Control for a TV focusing coil



Alignment was one of the problems involved in coupling the focusing control knob of this TV set to the focusing coil on the tube. Yet, note how simply a standard non-magnetic S.S.White remote control flexible shaft remedied the situation. By thus eliminating alignment problems, it was also possible to reduce other associated manufacturing and assembly costs.

FLEXIBLE SHAFT FACTS FOR DESIGNERS

BULLETIN 5306 gives basic information and data about flexible shafts and tells how to select and apply them. Write for a free copy. Address Dept. 4.

F-3

THE S. S. White INDUSTRIAL DIVISION
DENTAL MFG. CO.
10 East 40th Street
NEW YORK 16, N. Y.

Western District Office • Times Building, Long Beach, California

FICTION — Flexible Shafts Require Constant Attention

It's fiction, because with proper selection and application, S.S.White flexible shafts are good for the life of your equipment. As an example, consider the shafts that are used to drive the speedometer of your automobile. Even though a speedometer shaft turns millions of revolutions, at all speeds, in heat and cold — it is a rare case indeed where it has to be removed for maintenance or for replacement. A flexible shaft is as dependable as the Rock of Gibraltar!

How to stay ahead of your competition with Townsend special fasteners and parts

In today's highly competitive markets many design engineers and production managers find they improve products, reduce material costs and assembly time with Townsend's method of cold-forming fasteners and small parts. It enables them to put greater value into their products and at the same time hold unit costs down.

The Townsend method often replaces costly, material-wasting methods with savings that range from $.70 to $80.00 per thousand. Annual savings are often substantial—$15,816 on an automobile door lock part—$12,000 on a washing machine fastener—$11,190 on two parts for home laundry equipment—$15,630 on two refrigerator fasteners—$5,130 on an electrical connection.

Townsend engineers specialize in the assembly and fastening of all types of materials for all industry. They draw upon more than 10,000 standard and special items developed in 138 years of cold-forming experience and rely upon Townsend's capacity to produce 60-million pieces daily to give you the best in fastening methods. To learn how to improve fastening efficiency, ask to have an engineer call.

Townsend

COMPANY • ESTABLISHED 1816

NEW BRIGHTON PENNSYLVANIA

Sales Offices in Principal Cities

Cherry Rivet Division • Santa Ana, California

THE FASTENING AUTHORITY—Experience: *over 138 years*—**Capacity:** *sixty-million parts daily*—**Products:** *over ten-thousand types of solid rivets–cold-headed parts–Cherry Blind Rivets–Twinfast Screws–self-tapping screws–tubular rivets–locknuts–special nails–formed wire parts.*

Plants: *New Brighton, Pa.—Chicago, Ill.—Plymouth, Mich.—Santa Ana, Calif.*

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

News Roundup

is applied. The heat transferred from one end to the other of these thermojunctions is carried away by a flow of water through the system. Since there are no moving parts, the device is completely silent. New alloys and an effective assembly contribute to the overall efficiency of the refrigerator. Development of an all-electronic air conditioning system based upon the same principles is now under way.

Brightness of images projected upon a screen is intensified 20 times by an experimental light amplifier designed by RCA. A layer of light-sensitive material and a layer of electroluminescent material are sandwiched between transparent electrodes across which an alternating voltage is applied. A projected image striking the light-sensitive layer causes current to flow through the electroluminescent layer. The electroluminescent layer then emits its own light in a pattern corresponding to that of the original image. Intensity can be increased by increasing the votage.

While the present amplification ratio is only 20 to 1, a ratio of 100 to 1 is expected to be achieved. Ultimately, the light amplifier is expected to find wide application in television and radar.

An "Automation Dictionary" primarily designed "for those whose knowledge of automatic control is largely limited to setting the thermostat on the living room wall," has been published by the Industrial Division of Minneapolis-Honeywell. The 19-page booklet unlocks the secret of "engineerese" and the new language of automation in 87 clearly defined words and phrases for the average business man and industrialist.

A symposium on automation, "Automation—Engineering for Tomorrow," sponsored by the College of Engineering, will be held at Michigan State College May 12-14 as part of the Centennial celebration. Topics for the program for Mechanical Engineering include

Make ANGLgear your strong link

Photograph courtesy Oxy-Dry Corporation

No need to rely on chains and sprockets for right-angle transmission. Substitute an ANGLgear for a neater, more dependable job. The small size and heavy-duty design of this standardized bevel gear drive have won it a place in industry. ANGLgears are rated up to 2½ hp at 1800 rpm. All models are made with 1-1 gear ratio, and with 2 or 3-way shaft extensions. Contact your local distributor, or write us for details.

AIRBORNE
ACCESSORIES CORPORATION
HILLSIDE 5, N. J.

"Automation to Date," "Bases for Design of Automated Systems," "Automation as an Engineer Sees It," "Mechanical Design of Equipment for Automatic Production," "Management and Operational Problems," and "Automation—A Look Into the Future." Details may be obtained from Professor J. M. Apple, School of Engineering, Michigan State College, East Lansing, Mich.

Electrical Interest High Among High School Students

Electrical engineering seemed to draw the most interest at a science fair staged recently by the Technical Societies Council of New York and the New York Engineers Committee on Student Guidance.

About 960 high school students took part in 19 discussion groups, according to a report issued by the Engineering Manpower Commission. Attendance was taken at each group to give an indication of current interest in the various sciences. Electrical engineering led the 19 groups closely followed by aeronautical and rocket engineering. Top nine, in order of attendance, are as follows:

Electrical engineering
Aeronautical and rocket engineering
Physics, atomic energy
Chemistry
Medicine
Mathematics
Biology
Mechanical Engineering
Chemical engineering

Dentistry and science teaching were tied for tenth place. Mining was lowest of the 19 with only four of the 960 students reported in attendance.

Third Annual Technical Writer's Institute will be held at Rensselaer Polytechnic Institute, Troy, N. Y., June 13 through June 17. Courses are designed for those who supervise technical writing in business and industry, educational programs and technical promotion. Included in the courses are sessions on manuals and handbooks, reports, company-public relations, and associat-

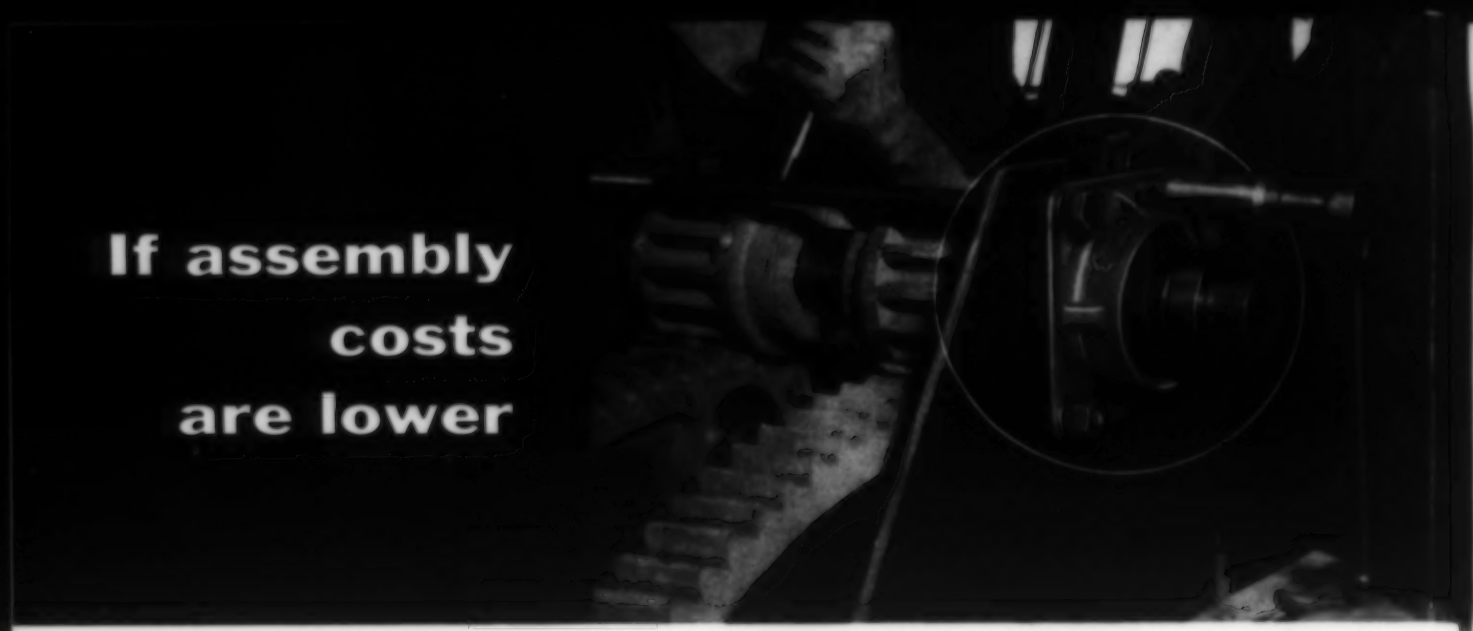
(*Continued on Page* 36)

Promet
Engineered Bronze
BEARINGS • BUSHINGS
WEARING PARTS
You needn't take our word for it. Take it from those who know: "We have formed a very high opinion of your products. They have served us well from a standpoint of wear and trouble-free usage. Your service and cooperation in expediting deliveries as required is very commendable."
—One of America's largest tool manufacturers.
"We find your Promet bronze of high quality and excellent in performance for use in our various pump assemblies. Your cast bronzes have excelled in their performance. Castings have also been of good sound quality."
—One of America's leading automotive parts manufacturers.
Write for free literature and service data sheets. Send blueprints, conditions of operation and other data for recommendations and quotations. You are invited to discuss your bearing problems with our metallurgists, engineers, and laboratory technicians.

THE American Crucible PRODUCTS CO.

. . . *bearing specialists since 1919*

1321 Oberlin Avenue
Lorain, Ohio, U. S. A.



If assembly costs are lower

chances are

Fafnir has a bearing on it

Type LEJ Self-Aligning Ball Bearing Flange Cartridge equipped with Wide Inner Ring Mechani-Seal Bearing and Self-Locking Collar. For shaft diam.: ½" to 3 15/16".

The installation of a Fafnir Ball Bearing Flange Cartridge on the pinion shaft illustrated is being made with a socket wrench. No complicated blue prints, no costly machining, no time-consuming fitting and adjusting of bearing. Assembly costs have been cut without cutting corners.

The use of a completely-housed ball bearing unit is only part of this cost-cutting operation. The *Fafnir Unit* offers additional cost savings. Its bearing inner ring is bored for a slip fit. The eccentric cam design of its inner ring and collar makes locking action positive with a twist of the wrist. No lock nuts or adapters are needed. No adjustments of any kind are necessary. The bearing can't be cramped or overloaded when mounting.

If you are looking for a way to cut assembly costs, maybe Fafnir can help you through better, more economical use of bearings. The Fafnir Bearing Company, New Britain, Conn.

MOST COMPLETE LINE IN AMERICA

FAFNIR BALL BEARINGS

CALL YOUR HOLO-KROME DISTRIBUTOR FOR

SAME DAY SERVICE

ON AMERICA'S TOP-QUALITY SOCKET SCREWS

Any Holo-Krome distributor in the nation can give you a brand of service never before enjoyed by users of socket screw products.

Because Holo-Krome ships all standard catalog items right from stock the same day the order is received!

What about Specials? We're proud to say that even the "impossible" ones are leaving the H-K plant in 4 weeks or better — mostly better!

Every day, more and more people specify Holo-Krome — because the price is right, the delivery's right and the quality's always Best!

We guarantee it! Next time, just say HOLO-KROME!

HOLO-KROME
Completely Cold Forged
SOCKET SCREWS

THE HOLO-KROME SCREW CORP. • HARTFORD 10, CONN., U. S. A.

Complete New Catalog

To Help You Select the Best Speed Reducer for Each Job

Horsburgh & Scott's new catalog provides you with all the information necessary for the proper selection of speed reducers.

- Complete size range available, including new sizes.
- New ratios and ratings for Worm Helical Speed Reducers shown.
- Increased Overhung Load capacities are listed and explained.
- Detail dimensions of standard worms and gears are given to help you "build-in" Horsburgh & Scott Speed Reducers.
- New Rating Tables—more complete than ever before—easier to use.
- Engineering Data Section—more tables and data you want.

All this information and much more is available in this catalog to you for the asking. Just write us on your letterhead for catalog 55—no charge, no obligation.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio

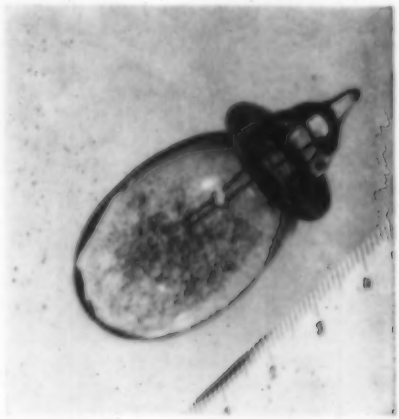
News Roundup

(*Continued from Page* 31)

ed fields. The week is devoted to lectures, personal consultations, group discussions, and writing practice exercises.

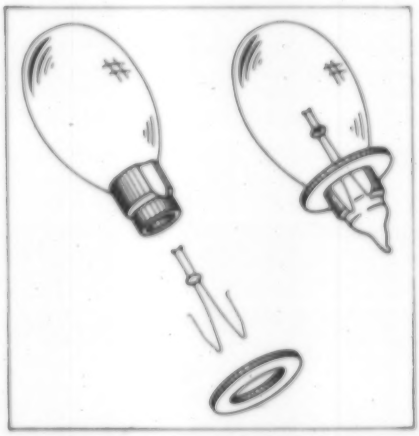
Glass Base Simplifies Photoflash Bulb Design

Elimination of the metal base of photographic flash lamps is expected to result in considerable reduction in costs. Developed by Phillips Research Laboratories of Eindhoven, Holland, the new construction greatly simplifies assembly besides eliminating material and fabrication of the metal bases.



Newly designed flash lamp in which the lead-in wires replace the metal base. Scale is in millimeters

Because flash lamps are used once, then thrown away, development has been aimed at keeping cost to a minimum. Much simplification was attained in the de-



Parts of the new Phillips glass-base flash lamp, left, and its assembly, right

sign of a bayonet type bulb to replace the formerly standard screw base type. More recently, American designers came up with a miniature bulb without bayonet pins, but with a simple collar arrangement to lock it in its socket.

Phillips engineers went even further and were able to eliminate the metal base completely by extending the lead-in wires out through the glass. These wires are bent over and held against the bulb with an insulating washer.

A special socket has been designed to hold the new bulbs. Phillips found that even the holders could be simplified and reduced in size. Adapters are said available to permit the bulb to be used with existing equipment.

• • • CORRECT TIME *will be found in a clock being developed by the National Bureau of Standards. Reported by Arthur D. Little Inc., the clock is based on the behavior of cesium atoms. These little particles, when acted upon by an external magnetic field, vibrate at a measurable frequency. The frequency of vibration is claimed to be measured to an accuracy of* 1 *second in* 300 *years. While earth-bound mortals are governed by common ordinary sun-to-sun time, cesium clock time is expected to be good on any planet.*

Army Developing "Family" of Engines

A military family of small industrial gasoline engines is being developed at the Corps of Engineers' Research and Development Laboratories, Fort Belvoir, Va. Working with industry, Army engineers are developing a family of seven engines in the ½ through 20 hp range to meet military requirements under adverse field conditions and when operating on military fuels and lubricants.

Both two and four-cycle type designs are being investigated. The program is aimed at meeting the requirements of numerous general-purpose applications within these horsepower capabilities. It stresses generator service, since the electric generator is the great-

Performing Seal!

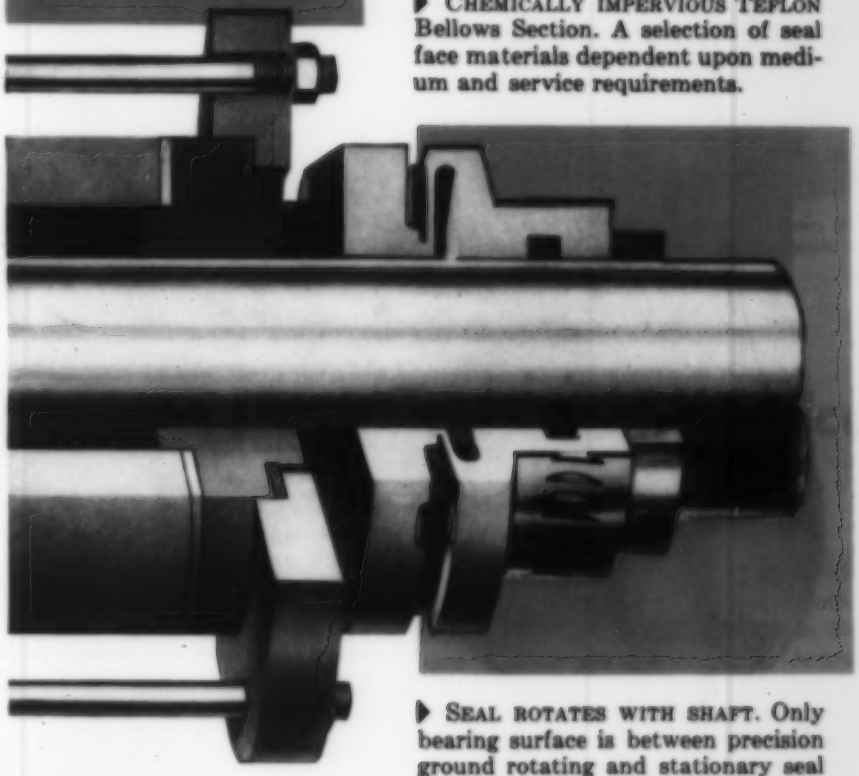
Service that no other Mechanical Seal can match

Pump difficult chemicals...with drop-tight service over longer periods of time. That is what Chemiseal's chemically impervious TEFLON, pressure-balanced bellows design offers you.

The ideal Mechanical Seal that has no equal in handling acids, alkalies, solvents, hydrocarbons, alcohols—clear liquids, slurries and tarry materials.

FEATURES

▶ CHEMICALLY IMPERVIOUS TEFLON Bellows Section. A selection of seal face materials dependent upon medium and service requirements.



▶ SEAL ROTATES WITH SHAFT. Only bearing surface is between precision ground rotating and stationary seal faces. Low friction load on shaft. Lower power cost. Drop tight service.

▶ NO SCORING OF SHAFTS and Chemiseals work satisfactorily on shafts previously scored by other seals or packing.

▶ PRESSURES at the seal up to 100 psi at 75°C or 75 psi at 100°C.

▶ SIZES from ⅜" to 2¼". Other sizes for special applications.

▶ MAXIMUM LENGTH, all seals 2¾".

Write for Bulletin No. MS-954.

made of du Pont TEFLON

UNITED STATES GASKET COMPANY, CAMDEN 1, NEW JERSEY

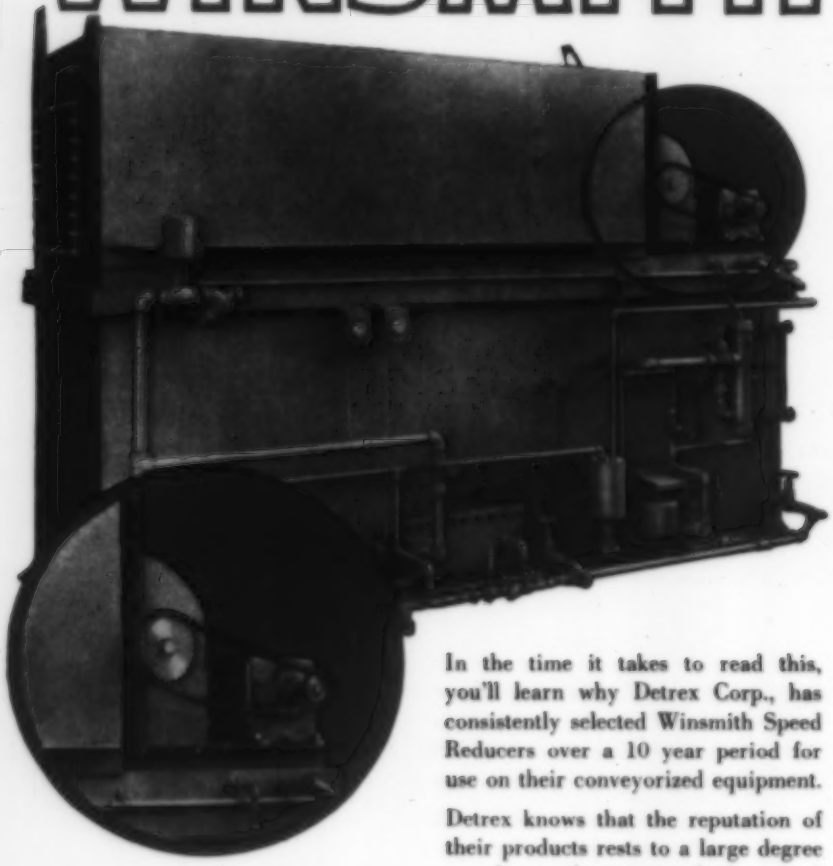
USG FABRICATORS OF FLUOROCARBONS & OTHER PLASTICS

Representatives in principal cities throughout the world

In less than 5 minutes...

BENEFIT FROM DETREX'S 10 YEARS EXPERIENCE WITH

WINSMITH SPEED REDUCERS



Detrex selected a 4½ DB Winsmith Speed Reducer for use on their unique rotary basket gyro degreaser. Driven by a ¼ hp motor at 1750 rpm with a reduction ratio of 960 to 1, the Winsmith reducer provides a smooth, vibrationless operation that eliminates the possibility of damage to delicate machined parts.

In the time it takes to read this, you'll learn why Detrex Corp., has consistently selected Winsmith Speed Reducers over a 10 year period for use on their conveyorized equipment.

Detrex knows that the reputation of their products rests to a large degree on the performance of the speed reducer they select. *Dependability* is their prime specification . . . and, Detrex reports "Virtually no failures in 10 years" as the reason Winsmith Speed Reducers are continually used on equipment carrying the Detrex Name Plate!

Apply this 10 year record of dependability to your own speed reducer problems! In addition to ruggedness and reliability, you can count on Winsmith for the most complete line of speed reducers from a single source within the range of 1/100 to 85 hp. in ratios of 1.1:1 to 50,000:1. A Winsmith power transmission specialist is available to discuss your speed reducer applications. You'll find him listed in the classified section of your phone directory; or, write Winsmith, Inc. direct.

...a single source for the most complete line of speed reducers within the range of 1/100 h.p. to 85 h.p. in ratios of 1.1:1 to 50,000:1

WINSMITH SPEED REDUCERS

WINSMITH, INC.
16 Elton St.
Springville, (Erie County) N. Y.

est single military application for engines in this range.

The new engines are being designed to operate efficiently for a minimum of 1500 hours before major overhauls are necessary. These engines will be easy to service and maintain, light in weight and designed to work under wide environmental extremes. It is estimated that only 800 to 1000 parts will be required to support the new "family" when developed.

Engines will be related by the use of many identical parts among sizes. For example, over 90 component parts will be identical in the 1½ and 3 hp engines alone.

The Laboratories and industry are also working together to alleviate maintenance and supply problems brought about by the use of many different makes and models of intermediate and large-size industrial gasoline engines. Much progress has been made in the field by standardizing the high-mortality parts, such as pistons, rings, bearings and valves. As a result of this program, the military services have procured approximately 16,000 industrial engines, incorporating these standardized parts, since July 1952.

Annual Doehler Award of the American Die Casting Institute for outstanding contributions to the advancement of the Die Casting process will be presented in September during the annual meeting of the American Die Casting Institute. Nominations for the Award and supporting papers or other material should be sent to: Award Committee, American Die Casting Institute, 366 Madison Ave., New York 17, N. Y. Entries will be received until April 15.

New order index of industrial supplies and machinery hit the highest point in 15 months in December. The American Supply and Machinery Manufacturers' Association reports the new order index for December at 148.8. This is the highest point reached since September, 1953, when the index stood at 150.6. Previous high for

1954 was 148.1 in September. The index measures the flow of orders received by Association members who are manufacturers of production and maintenance equipment, tools and supplies selling to industry through industrial supply distributors. The value of orders received during December was almost 2 per cent more than November and almost 49 per cent over the base month of July, 1948.

Research on analog computers at Carnegie Tech has been given a $10,000 boost in the form of a grant by the L. H. Tarpening Co. to the Electrical Engineering Dept. Presented by Mr. L. H. Tarpening, president, the grant was made to establish four fellowships for graduate electrical engineers who are earning their doctorates in the field of analog computers.

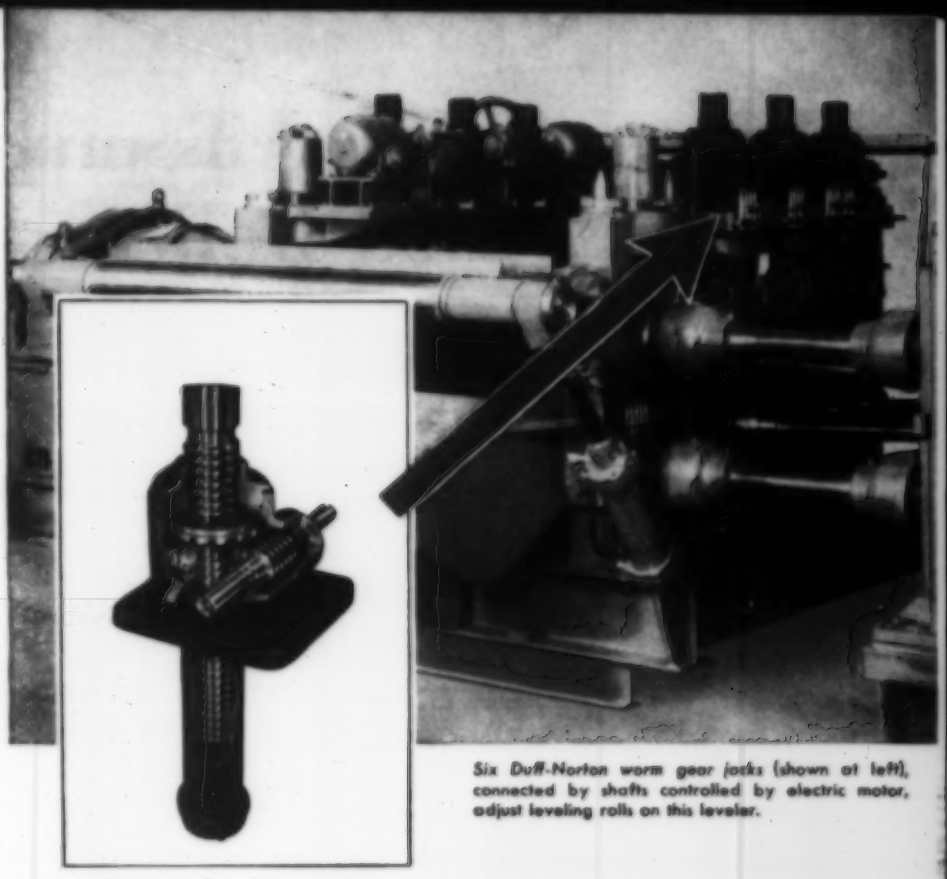
Designers Must Find New High-Temperature Metals

High temperatures produced by ram-jet engines, afterburners for turbojets, and rockets threaten to melt present high-temperature metals. So stated Alan V. Levy of Marquardt Aircraft Co. in a paper presented to the Society of Automotive Engineers at the recent Aircraft Research Seminar in Los Angeles.

Metals to withstand temperatures in the range of 1200-2400 F must be found, he asserted. Engines operating with hot-spots at 2200-2300 F are within 200-300 F of the melting temperatures of the best high-temperature alloys. These engines cannot attain the improved performance that comes with operation at higher temperatures until new materials are found or cooling methods are used.

Levy pointed out that the designer must look to molybdenum, ceramic coatings or the combinations of ceramic materials and metals for future high-temperature metals. He said that the classes of metals retaining sufficient strength to be used at temperatures above 1200 F are alloys which have iron,

(*Continued on Page 42*)



Six Duff-Norton worm gear jacks (shown at left), connected by shafts controlled by electric motor, adjust leveling rolls on this leveler.

Here's a time-tested device for adjusting machinery

It's the Duff-Norton worm gear jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion; applying pressure; resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes or any power-operated positive control system, so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 35 tons with any raise up to 25 inches; worm gear ratios, 8:1 to 45:1; turn of worm for each 1 inch raise, 10 to 180; available in either Acme or square threads. Screw ends and tops are available in many types and can be readily adapted to your specific requirements.

Duff-Norton worm gear jacks have been specified by America's leading designers and machinery builders for many years. They are made in 6 standard sizes or to your special order. Write for booklet!

DUFF-NORTON
Manufacturing Company

The Duff-Norton Manufacturing Co.
P. O. Box 1889, Pittsburgh 30, Pa.

Please send immediately a free copy of your Worm Gear Jack Booklet.

NAME_____ TITLE_____

COMPANY_____ PHONE_____

ADDRESS_____

(Advertisement)

How to Control Temperature With Liquid Filled Bellows Systems

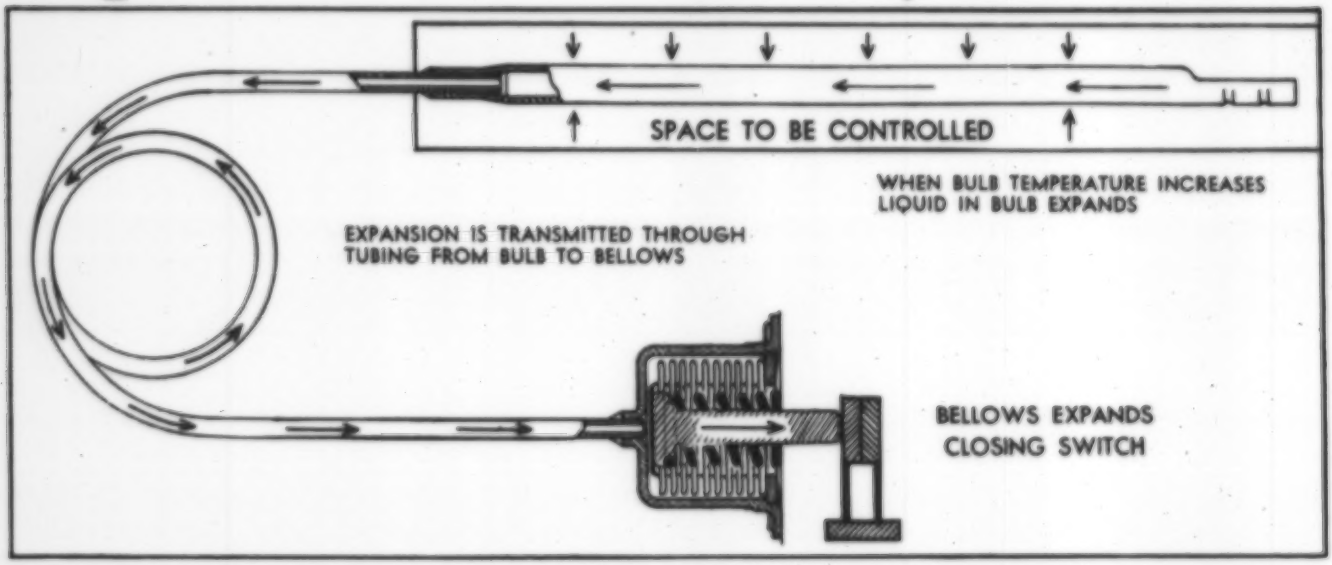


Fig. 1. Liquid filled bellows systems provide remote control of a wide temperature range with a single adjusting device. Bellows actuating movement is closely proportional to the temperature range throughout the entire operating range of the system. The differential required to operate these devices is directly related to the range of temperature to be controlled. A device that provides control over a wide temperature range normally requires a relatively wide differential to operate it at any given setting. However, proper design of switches or valves can make these systems quite sensitive.

ADVANTAGES OF LIQUID FILLED BELLOWS CONTROLS

For the remote control of temperature, liquid filled bellows assemblies provide simple, efficient, direct-acting systems. Utilizing the thermal expansion of a liquid selected for the particular application, the bellows responds with sufficient force and degree of motion to actuate switches and valves without the need for elaborate amplifying systems.

They can be used for temperatures as low as —100 F. and as high as 700 F. In addition, these units provide "one knob control" of temperature over a *wide range*. A common example is the ordinary domestic oven in which a selected temperature can be maintained anywhere in the range from 150 F. to the top limit of the oven — usually about 600 F.

Since these systems operate on the thermal expansion of a liquid, they are insensitive to ambient pressure changes.

Liquid filled bellows systems are highly versatile and offer many possibilities to designers seeking low cost, accurate, dependable temperature controls for consumer, industrial or commercial product applications.

Long experience record. Being one of the most widely used thermostatic controls, a great deal is known of the inherent characteristics of liquid filled thermostatic assemblies. Performance can be accurately predicted for applications when operating conditions are known. Furthermore, the design considerations are so well known that it is usually not difficult to design a liquid type thermostatic assembly to fit the requirements of any application for which this type of control is suited.

Operating principle. (fig. 1). In its simplest form, the liquid filled thermostatic assembly consists of a bulb, capillary and bellows. The bulb is the temperature-sensing element and is located in the chamber whose temperature is to be controlled. The bellows is the responsive element and can be located together with the switch or valve it will actuate at any remote location within a reasonable distance of the bulb. A capillary, a special small bore tubing, connects bulb and bellows. The entire assembly — bulb, capillary and cup — is completely filled with a liquid chosen for the particular range of temperature to be controlled.

As the temperature in the chamber rises, the liquid in the bulb expands through the capillary into the cup, compressing the bellows and moving the attached rod to actuate a switch or valve.

DESIGN CONSIDERATIONS

Bellows stroke. The amount of bellows movement necessary to actuate the switch or valve varies with the nature of the application. Design of bulb volume and bellows effective area control the movement to meet these requirements. A large volume bulb and small bellows results in a longer stroke and vice versa. Bellows of 15/32" or 9/16" diameter are common sizes.

The total stroke or travel to be ex-

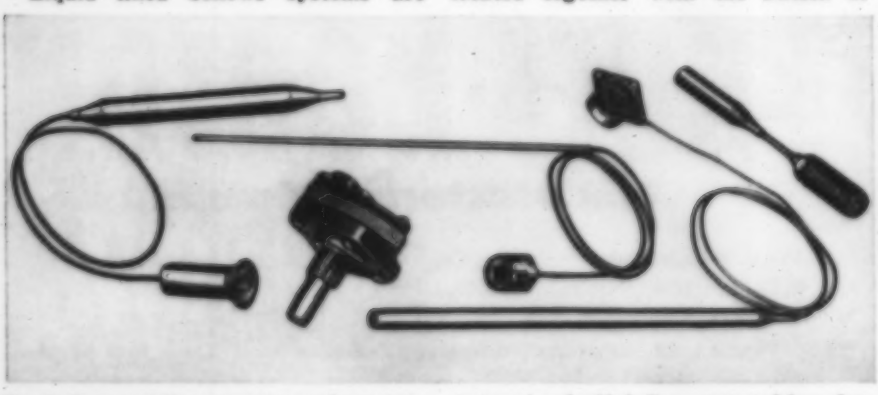


Fig. 2. Representative open type and cup type filled bellows thermostatic assemblies. Cup type is preferable, being inherently stronger, easier to mount and with bellows protected from damage by handling.

Fig. 3. Electric and gas ranges are commonly equipped with liquid filled bellows controls. Bellows movement operates electric switches that turn heating elements on and off. In gas ranges bellows operates modulating valve to control flow of gas.

Fig. 4. Control of temperature for many industrial processes is achieved through liquid filled bellows assemblies. Typical applications: Kilns, steam tables, kettles, ovens, furnaces.

pected of a bellows in this type of application is approximately 25% of its length.* This is the total amount of bellows movement available over the entire range of temperature which the device will encounter.

For example: a bellows one inch long will provide a total travel of about one-quarter inch.* Used in a temperature range of 500 F, bellows movement would be .0005" per degree. In a 100 F range, movement per degree would be .0025".

In computing bellows movement care must be exercised to consider the highest ambient temperatures encountered during shipment, storage or extraordinary conditions of service. Heat applied to a fluid in a closed system can generate large forces and result in damage. A unit intended to control temperatures between 50 F and 70 F for example, may experience temperatures as high as 140 F. Bellows movement must therefore be figured for the range 50 to 70 F (Normal ambient) resulting from expansion of the liquid in the bulb. In addition, the entire volume of liquid in the bulb, bellows and capillary will expand between 70 and 140 F.

∴Coeff. of Expansion [Bulb Volume × (70 − 50) + (Bulb + Bellows + Capillary volumes) × (140 − 70)] gives total liquid expansion. This expansion divided by the effective area of the bellows will give the total movement over the complete range from 50 to 140 F. The total movement should not exceed the allowable travel discussed above. Temperatures *lower* than the operating range need not be considered as a factor.

Loading springs are generally used with liquid filled bellows systems. They make certain that the bellows follows the volume changes of the liquid accurately. Springs used for cup type assemblies are lighter than those required for equivalent open type assemblies (see fig. 2) because the natural spring of the bellows in a cup assembly actually helps the loading spring to perform its proper function. The open type bellows assembly opposes the loading spring and therefore, a heavier loading spring is required. Frictional forces for devices utilizing cup type assemblies are generally lower than those for equivalent open type units.

Bulb and filling medium. There are a number of liquids with properties suitable for use in thermostatic assemblies intended for service anywhere from −100F to 700 F. Some typical ones are shown in fig. 7. In addition to the consideration of adequate volume in relation to the bellows so as to provide sufficient actuating stroke, bulb design is concerned with securing the proper heat transfer so that temperature changes in the controlled chamber will be quickly reflected in bellows movement. Both filling medium and bulb design are critical elements and should be chosen only after consultation with Clifford engineers.

Responsiveness of liquid filled bellows assemblies is very good and they can be used in systems requiring rapid response. The only heat required to change the temperature of the bulb is that required by the specific heat of the bulb material and its enclosed liquid. Much depends upon the specific conditions of the application. In rapidly moving air, for example, time constants as low as 10 seconds are practical. When the bulb is immersed in a liquid the device may operate up to five times as fast.

The open type thermostatic assembly is used for some applications where cup type (fig. 1) may not fit. Operating principle is the same except that the bellows itself is filled with liquid and expands with rise in temperature to actuate the switch or valve rather than being compressed as in cup type.

Open assemblies require a heavier loading spring than the cup type. The bellows is more susceptible to damage due to handling and it is more difficult to mount this type of assembly. Cup assemblies are more rugged. They protect the bellows and apply the pressure to its outside surface. The bellows operates in compression — for which it is best suited, resulting in longer life.

Clifford will send you additional data. If you have an immediate problem, send a sketch showing controlling conditions. We will recommend a suitable control.

Clifford Manufacturing Company, 124 Grove Street, Waltham 54, Mass. *Division of Standard Thomson Corporation.* **Sales Offices in New York, Detroit, Chicago, Los Angeles, Waltham, Mass.**

Coefficients of Thermal Expansion

	Coefficient* (in.³/in.³/deg F) × 10⁻⁶ (0 – 1 – 2)	Freezing Point (F)	Boiling Point (F)	Max. Op. Temp. (F)
Mercury		− 38	675	
H. T. A.†			672	600
Glycerine			554	350
H. T. C.†		29	525	700
H. T. B.†		54	500	700
Trichlorobenzene		45	415	450
O-Toluidine		3	392	450
Ethylene Glycol		11	388	350
Aniline		− 22	364	450
O-Dichlorobenzene		2	357	450
Chlorotoluene		− 35	321	450
Turpentine			311	350
Xylene		− 53	283	400
Monochlorobenzene		− 50	269	450
Glycerine-Water (62:38 vol.)		− 45	235	350
Toluene		−139	231	400
Water		32	212	
Trichloroethylene		− 99	188	250
Benzene		42	176	300
Ethyl Alcohol		−174	173	250
Carbon Tetrachloride		− 9	170	250
Methyl Alcohol		−143	148	300
Chloroform		− 82	142	250
Acetone		−138	133	250
F-113		− 31	118	250
Methylene Chloride		−142	104	300
Ethyl Ether		−177	94	250
F-11		−168	75	250
Ethyl Chloride		−218	55	350
F-21		−197	48	250
Methyl Bromide		−137	38	250
Butane		−211	31	400
Sulphur Dioxide		−105	14	800
Isobutane		−229	10	400
Methyl Chloride		−143	−11	400
F-12		−247	−22	250
Ammonia		−107	−28	
Propane		−310	−44	400

* Values increase with temperature; for example, coefficient for trichlorobenzene ranges from 0.00044 in the region of its 45 F freezing point to 0.00070 at its recommended maximum operating temperature, 450 F.

† Special high-temperature service compounds.

Fig. 6. Representative filling mediums for liquid type assemblies.

* *For accurate information, refer to bellows table of characteristics obtainable upon request.*

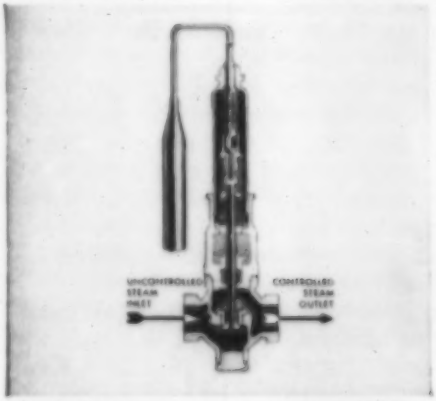


Fig. 5. Steam regulators are typical applications for liquid filled bellows assemblies. Cross section shows a Leslie Temperature Regulator used in cooling service. The rugged thermostatic element has an adjustable temperature range up to 350 F.

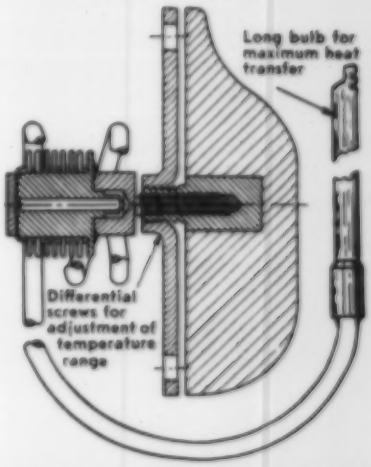
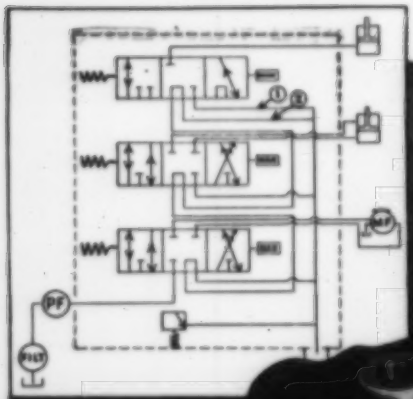


Fig. 7. Open type liquid filled control with adjusting mechanism. Similar mechanisms can be provided for cup type. 7.4.81

HYDRON
CLIFFORD
MANUFACTURING CO.
WALTHAM, MASS.

Your Hydraulic Circuit in a Nutshell with a HYDRECO HOLLOW PLUNGER CONTROL VALVE



V-13 Series 3 Plunger Valve with piston-type Relief Valve. Location of ports and controls reversible. Available 1 to 5 plungers...5 to 80 gpm.

Raise or lower the load with throttled smoothness . . . hold it at any point with no "sag" or drop.

Tilt the platform forward or back quickly and without shock while standing still or in motion.

Hold the load securely clamped . . . or provide other lateral or rotary motion time and labor-saving functions.

Reducing the "spaghetti" in a circuit is heads-up engineering, but this is just one of the many advantages you enjoy with HYDRECO Control Valves. What can a valve do for you? What have you a right to expect of a hydraulic valve? HYDRECO answers these questions with definite performance history that shows how your machines can do more – *Quickly – Precisely* and *Dependably!* You put *complete* control at the fingertips of the operator when your equipment features –

HYDRECO Oil Power!

Earth Moving and Materials Handling operations probably represent the most rigorous service hydraulic components are called upon to perform. It is significant that HYDRECO Valves, Pumps, Motors and Cylinders are the most frequently used in these fields. To improve the performance of existing equipment or to add functions and complete dependability to projected designs – get all the facts on HYDRECO Oil Power.

Write for full information on HYDRECO Control and Auxiliary Valves . . . accept the assistance of HYDRECO engineers and their experience in developing "circuits that work".

HYDRECO DIVISION
THE NEW YORK AIR BRAKE COMPANY
1106 EAST 222nd STREET • CLEVELAND 17 • OHIO
INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

News Roundup

(*Continued from Page 39*)

nickel or cobalt as the major constituent. These three elements are the foundations of today's high temperature metals, although work is being done on new metals based on molybdenum, titanium and chromium.

One big drawback, according to Levy, is the scarcity of these materials in the United States. Government regulations control the alloy content in the design of aircraft and missile power plants. Designers must continually keep in mind the critical elements in the design of high-temperature equipment.

Another great difficulty was said to be the problems in fabrication of high-temperature alloys. Generally, they can be welded, formed or cast, but are practically unmachinable.

Cost, Levy stated, is normally of minor consideration. High-temperature alloys, although more costly than low-temperature metals, are a necessity in the construction of these power plants. Since nothing else will do the job, the designer has no choice cost-wise.

Basic Materials Show To Include Design Applications

Announcement of the 1955 Basic Materials Exposition disclosed that the scope of the show will be broadened to include design applications of materials.

To be held in Philadelphia from May 31 to June 3, the show will be subtitled "The Design Engineering Show." Exhibits have always been restricted to materials which go into the making of end products for consumer and industrial use. This year, however, certain manufactured products will be shown. But these will be parts, shapes and forms that are themselves included in the manufacture of end products.

Purpose of the expanded range of exhibits, according to the show's management, is to provide a common meeting ground for design enginners.

A three-day conference will be held along with the exhibition. Ad-

vance registration and information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

PRINTED CONTROLS: These printed circuit panels are said to be the first printed circuitry ever incorporated into industrial control equipment. Made by General Electric, the printed boards can be inspected for circuit faults at a glance

Begin Design of Army "Package" Reactor

A power reactor plant will be built by a private corporation for the U. S. Army, according to the Atomic Energy Commission. Contracts have been awarded the American Locomotive Co. to design, build and test operate a nuclear power plant having components transportable by air.

Although the new plant will be designed for a capacity of only 2000 kilowatts of electrical power, its main purpose will be to supply information on the capabilities and limitations of other such plants. Experience gained in the construction, operation and maintenance will be valuable in the planning of future plants.

To cost over $2 million, the prototype will be built at Fort Belvoir, Va., site of the Army Corps of Engineers training center. Army

A New High Pressure Pump at a Low Pressure Price

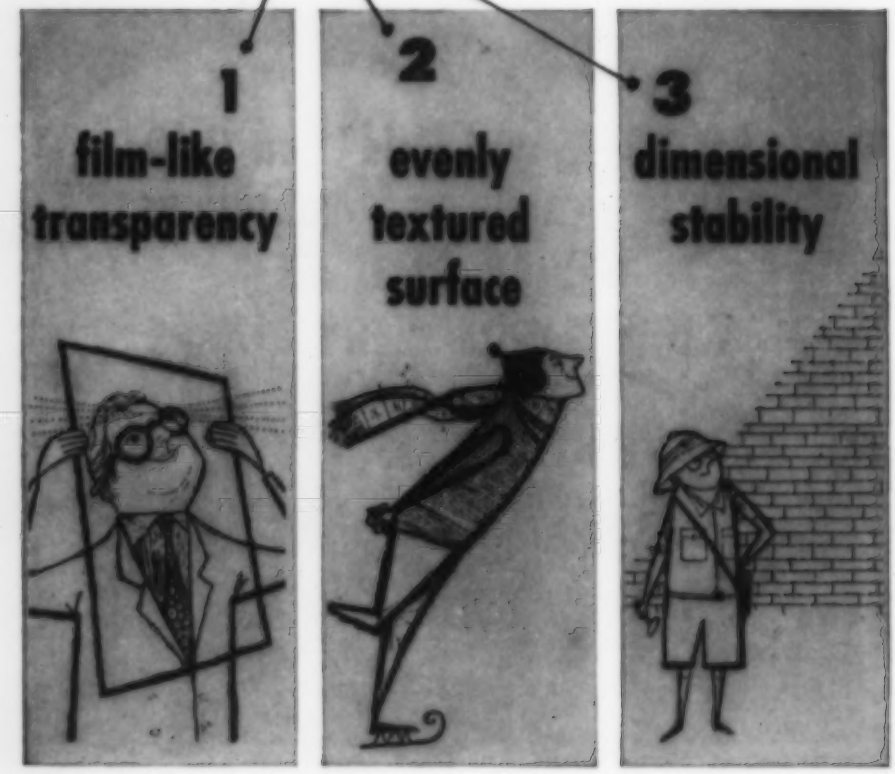
The DUDCO PV-600 Series Variable Delivery Pumps give designers and users a source of Fluid Power that sets new standards of efficiency, flexibility, performance AND economy. Design features eliminate excessive heat . . . major cause of accelerated wear, bearing failure and pump deterioration. And, these pumps operate with maximum performance with an exceptionally wide range of hydraulic fluids . . . oils, synthetics and non-flammables.

Available in Pressure Compensated and Hand Wheel Control types. The PVC Models provide integral pressure control where regulation is achieved within the pump itself. At zero flow, the pump operates at normal speed and maintains holding pressure with negligible power consumption. The PVM Models incorporate a manually operated flow regulator that affords accurate adjustment of delivery between the limits of full flow and zero flow. Output of this pump can be speedily adjusted to meet the flow requirements of the machine being operated.

Get all the facts on this PV-600 Series. Write for Bulletin DP-350 and other new developments in DUDCO DUAL-VANE PUMPS and MOTORS.

DUDCO DIVISION
THE NEW YORK AIR BRAKE COMPANY
1706 EAST NINE MILE ROAD • HAZEL PARK • MICH.
International Sales Office, 90 West St., New York 6, N. Y.

which tracing medium has all three?



PTM looks like a film and *prints* like a film—no other medium in its price range can approach its transparency! For greater contrast and finer prints, your wisest choice is PTM.

PTM has a flawless, velvety mat surface with complete uniformity in every direction. Erasures leave no ghosts. The glossy back resists dust—keeps your drawings *clean!*

PTM has unusual density to resist atmospheric changes. It is the most stable of all tracing papers; a reliable medium for dependable, close-tolerance drawings!

PTM®
POST TRACING MEDIUM
has all three!

Send the coupon today for free sample and fact file

**Patent No. 2413764*

POST
FREDERICK POST COMPANY

Frederick Post Company
3652 N. Avondale Ave.
Chicago 18, Ill.

Gentlemen:

At no obligation to me, please send the "PTM Fact File" with a sample sheet of PTM and price information on various sized rolls and sheets.

Name.....

Address.....

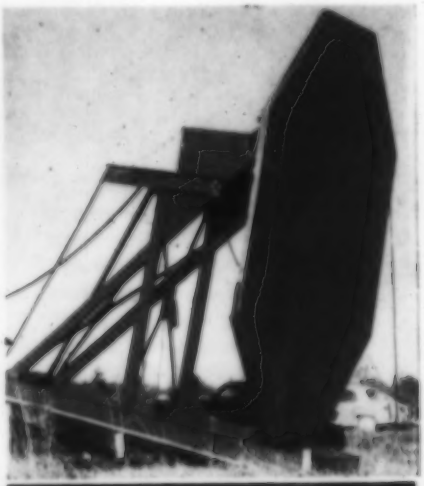
City..... Zone..... State.....

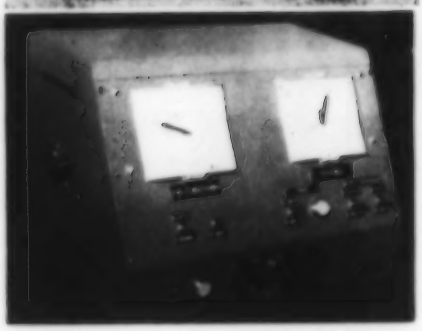
Milwaukee • Detroit • Houston • Los Angeles • Englewood

officials hope to incorporate its functions into the engineer training program.

Sun Follower Studies Radar Waves

Precision tracking to study radio waves emanating from the sun is accomplished with a 1½-ton device made for the Air Force Cambridge Research Center on a Cornell University subcontract. Mounted on bearings paralleling the axis of the earth, the plane





Reflector of the radar heliostat, above, is 15 feet long and 8 feet wide. It has been tilted to allow for a difference in latitude between the test site and its final place of operation. Control panel, below, provides indications of position

reflector is driven by a one-revolution per day tracking drive. A second traverse enables the device to be moved rapidly to any position desired, and a declination drive may be used to compensate for variations in the sun's height from day to day.

Cost of this special device has

been held to a minimum by mounting it on a standard Aronson welding positioner according to its makers, A. F. Gagne Jr. Associates. Precision position indication is achieved using a selsyn system rather than a more expensive and complicated gearing system.

• • • POLKA-DOT PAINT *is now a reality, according to Arthur D. Little Inc. Fine droplets of different-colored lacquer are suspended in an aqueous medium. The color used in the largest quantity appears as the background when the lacquer is sprayed. The other colors appear as dots in relief on the surface. Now it's up to someone to beat the next big paint problem—plaid paint.*

Conveyor Oils Railroad Bearings

A combination of rubber belts and nylon rollers makes up a lubricant conveyor designed for delivering a constant bath of oil to railroad journal bearings. Installed in the bottom of the journal box, the unit assures a supply of lubricant to the journal regardless of train speed or oil level.

A kit, designed by National Motor Bearing Inc., includes the oil seals and special guard bearings. Purpose of these items is to replace the waste packing method of oiling unsealed journals.

To make the new oil-bath method effective, NMB designers first designed an effective shaft seal to prevent leakage from the rear of the box. The seal consists of a lip section, a bellows section, and a locking assembly. Its design permits it to lock itself in place and maintain an effective seal in spite of lateral movement of the axle.

Guard bearings have also been incorporated in the new design. Specially compounded rubber bearings are bonded to ductile-iron castings. Purpose of these bearings is to cushion or check sudden shocks common to railroad-car operation.

Synthetic rubber belts rolling on six nylon rollers make up the conveyor assembly. The entire as-

(*Continued on Page* 48)

You needn't be a gear engineer to use this new Reducer Catalog...

• BRAD FOOTE'S new Speed Reducer Catalog is easy to use. It contains simple instructions on how to choose and how to order. It tells you what job factors to consider and the reasons why. It eliminates the "mysteries" of speed reducer selection.

• Horsepower rating tables* and dimension charts are printed in large easy-to-read type. Pages are uncrowded and easy on the eyes. Every figure and every dimension can be located quickly. Complete index speeds finding the data you need. So do the index markers at the top of each page.

• In the new No. 120 Speed Reducer Catalog, BRAD FOOTE helps you choose the reducer you need from single, double or triple reduction parallel shaft, and double and triple reduction right angle types. It's as easy as A, B, C.

Write today for your free copy

*Conform to AGMA standards

BRAD FOOTE GEAR WORKS, INC.

1309 South Cicero Avenue • Cicero 50, Illinois
Bishop 2-1070 • OLympic 2-7700 • TWX: CIC-2856-U

subsidiaries

AMERICAN GEAR & MFG. CO.
Phone: Lemont 920
Lemont, Illinois

PITTSBURGH GEAR COMPANY
Phone: SPaulding 1-4600
Pittsburgh 25, Pennsylvania

DELCO
DAYTON OHIO

On-Time

Volume depend

"The lady who is wise will ask to be advised if it's powered with a Delco Electric Motor."

Dependability of *delivery* means a lot to a volume producer, and many a customer has learned that he can expect it—and get it—from Delco Products. He knows that whatever the size of his order, Delco will deliver, *when* he wants it, *where* he wants it.

And there's another kind of Delco dependability, too—the dependability that Delco

Watch for Delco Electric Motor national advertising now appearing in The Saturday Evening Post.

Producers on Delco!

Electric Motors bring to your product. Delco Electric Motors are job fitted to your products by our engineers working with your engineers. The motors are thoroughly tested in specific applications. Finally, they are put into production . . . built to a high standard, with mechanical and electrical qualities guarded all the way by rigid control. That's why every Delco Electric Motor gives top-notch, completely reliable performance.

Delco parts and service facilities are available the world over.

Delco Products, Division of General Motors,
Dayton, Ohio

GM GENERAL MOTORS DELCO

DELCO *Electric* MOTORS

PRODUCT OF GENERAL MOTORS

Proved best by Performance!

SEARCHING
AND
RESEARCHING

For Alloy Powder Combinations?

If you need a specific alloy combination to fill a specific requirement, the Metallurgical Division of Metal Hydrides can help you. With seventeen years of pioneering with metal powder alloys, Metal Hydrides' Metallurgists can give you unmatched know-how assistance plus volume production of alloy combinations that meet your exact requirements. Metal Hydrides' alloy powders are clean, uniform in composition, and controlled in particle size to assure desired results.

Contact Metal Hydrides now. Complete information is yours without obligation.

Pioneers in Hydrogen Compounds

MH

Metal Hydrides
INCORPORATED

15 CONGRESS STREET, BEVERLY, MASS.

News Roundup

(*Continued from Page* 45)

sembly is mounted on a wide U-shaped flat spring and rests in the oil at the bottom of the journal box. As the axle rotates, its contact with the belts cause them to pick up the lubricant and splash it on the journal.

About 35 designs were tested before an acceptable one was found, the company reported. The present assembly is expected to last the life of the car.

Bendix Aviation Corp. has announced the change of name of Eclipse-Pioneer Foundries Div. to Bendix Foundries. The change was made to emphasize the division's policy of serving the needs of a wide range of industrial customers in the aviation, electronic, and marine fields.

Reliance Electric & Engineering Co., Cleveland, has acquired the **Reeves Pulley Co.** of Columbus,

---

ACCURATE NOZZLES shown here are highly polished and calibrated. They are used by General Electric in the study of the effect of air flow through traction motors and generators in the hope of improving heat-transfer characteristics of the machines

Ind. Reliance is a producer of electric motors and electronically controlled drive systems. Reeves manufactures mechanical variable-speed transmissions and drives. Management at Reeves will remain intact and continue operation as a separate division of Reliance.

Douglas C. Lynch, executive vice president of Brush Electronics Co., has been elected president, according to James L. Myers, chairman of the board of Clevite Corp. W. Russell Burwell, former Brush president, will devote full time to his position as vice chairman of the board and as chairman of Clevite's Research and Development Committee, according to the announcement.

Baker Mfg. Co., Springfield, Ill., has been purchased by Allis-Chalmers Mfg. Co.

Meetings

AND EXPOSITIONS

Mar. 23-24—

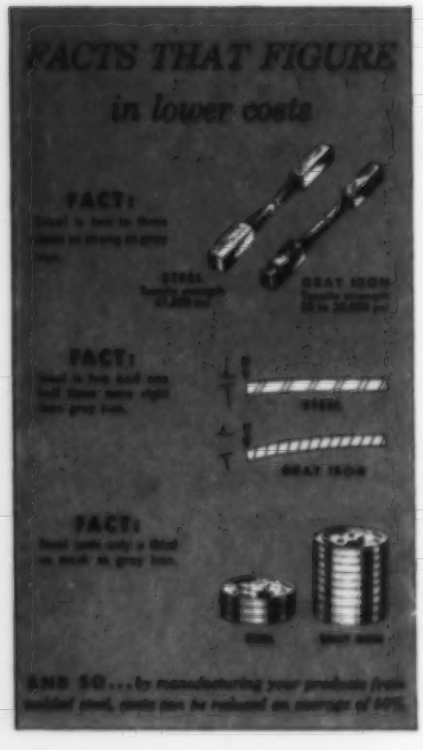
American Society of Mechanical Engineers. Management conference to be held at Hotel Statler, Cleveland, O. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Mar. 28-29—

American Institute of Electrical Engineers. Materials handling conference to be held at Hotel Cleveland, Cleveland, O. Additional information may be obtained from society headquarters, 33 West 39th St., New York 18, N. Y.

Mar. 28-Apr. 1—

American Society for Metals. Western metal exposition and congress to be held at the Pan Pacific Auditorium, Los Angeles, Calif.

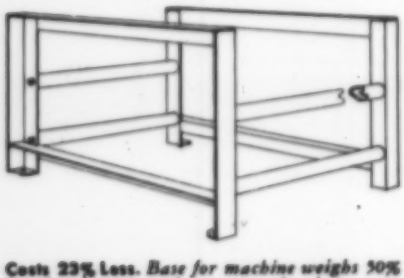


WHAT MAKES PRODUCT DESIGNS SUCCESSFUL

ONLY when a product can be manufactured and sold at a profit is it considered successful by industry. To meet competition today, the product must be built at lowest possible cost.

The engineer who can create economical designs finds rewarding demands for his talents by manufacturers everywhere.

To achieve low costs, manufacturers are turning to welded steel construction on many of their products. Material costs less and fewer pounds of metal are needed to do the same job as with iron. Manufacture is simpler with welding . . . takes fewer shop hours to effect cost savings up to 50% on most designs.



Costs 23% Less. *Base for machine weighs 50% less than former casting construction, is stronger, more rigid, neater in appearance. Fabricated in only 6 hours . . . former design took 14 hours.*

How to design in steel

Handbook and bulletins on welded design are available to designers and engineers by writing:

THE LINCOLN ELECTRIC COMPANY
Dept. 1101
Cleveland 17, Ohio
THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

Engineering News Roundup

Additional information may be obtained from society headquarters, 7301 Euclid Ave., Cleveland, O.

Apr. 6—

American Society of Mechanical Engineers. Machine Design Div. conference to be held at the College of Engineering, New York University. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Apr. 6-10—

World Plastics Fair and Trade Exposition to be held at the National Guard Armory, Los Angeles, Calif. Additional information may be obtained from Fair Management, 8762 Holloway Drive, Los Angeles 46, Calif.

Apr. 13-15—

American Society of Lubrication Engineers. Tenth annual meeting and exhibit to be held at the Sherman Hotel, Chicago, Ill. Secretary is W. P. Youngclaus, Jr., 84 East Randolph St., Chicago 1, Ill.

Apr. 16-17—

Packaging Machinery Manufacturers Institute. Spring meeting to be held at the Palmer House, Chicago, Ill. Additional information may be obtained from society headquarters, 342 Madison Ave., New York 17, N. Y.

Apr. 18-21—

American Management Association. Packaging conference to be held at the Palmer House, Chicago, Ill. Additional information may be obtained from society headquarters, 330 West 42nd St., New York 36, N. Y.

Apr. 18-21—

American Society of Mechanical Engineers. Spring meeting to be held at the Lord Baltimore Hotel, Baltimore, Md. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Apr. 25-27—

Association of Iron & Steel Engineers. Spring conference to be held at the Statler Hotel, Detroit, Mich. Managing director is T. J. Ess, 1010 Empire Bldg., Pittsburgh 22, Pa.

Apr. 27-29—

Society for Experimental Stress Analysis. Spring meeting to be held at Hotel Statler, Los Angeles, Calif. Secretary-treasurer is W. M. Murray, P.O. Box 168, Central Square Station, Cambridge 39, Mass.

Apr. 28-29—

American Zinc Institute Inc. Annual meeting to be held at the Drake Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 60 East 42nd St., New York 17, N. Y.

May 10-12—

Metal Powder Association. Annual meeting and exhibit to be held at the Bellevue-Stratford Hotel, Philadelphia, Pa. Additional information may be obtained from society headquarters, 420 Lexington Ave., New York 17, N. Y.

May 16-20—

Materials Handling Exposition to be held at the International Amphitheatre, Chicago, Ill. Details are available from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

May 23-25—

American Society for Quality Control. Annual meeting and exhibit to be held at the Statler Hotel, New York. Additional information may be obtained from society headquarters, 50 Church St., New York 7, N. Y.

May 23-25—

American Foundrymen's Society. Annual meeting to be held at the Rice-Shamrock Hotel, Houston, Texas. Additional information may be obtained from society headquarters, 616 South Michigan Ave., Chicago 5, Ill.

May 30-June 10—

Canadian International Trade Fair to be held at Exhibition Park, Toronto, Ontario, Canada.

MEN
OF MACHINES

Formerly manager of engineering, **John D. Russell** has been appointed vice president of engineering by Joy Mfg. Co., Pittsburgh. Mr. Russell has served the company in various engineering capacities since his graduation.

John D. Russell

with a degree in electrical engineering, from Cornell University in 1930. He is a member of the Cornell Society of Engineers and the Northwest Pennsylvania Engineering Society.

Martin V. Kiebert Jr. has been appointed assistant to the chief engineer of Convair, a division of General Dynamics Corp., Pomona, Calif. He was formerly chief engineer of the Tuner Div. of P. R. Mallory Co.

A new firm, Atomic Energy for Industry Inc., has been formed by **Charles H. Lutz** in Cleveland. Dr. Lutz will remain affiliated, as a special consultant and associate staff member, with Designers for Industry Inc., where he has been a specialist in electronics and the industrial applications of atomic energy.

Daystrom Instrument Div. of Daystrom Inc., Archbald, Pa., has named **Nelson H. Mageoch** to the position of vice president for operations. Formerly associated with General Electric Co., Atwater Kent and Western Electric Co., Mr. Mageock came to Daystrom in 1951. He was made chief engineer in June 1952 and became director of research and engineering a year later. In May 1954 he was promoted to vice president of research and engineering.

Consolidated Engineering Corp., Pasadena, Calif., recently appointed **Armand F. DuFresne** to the newly created position of chief product engineer. Mr. DuFresne will head a new product engineering department which will be responsible for translating newly developed instruments into designs for manufacture and use.

New York Air Brake Co., New York, has appointed **Thomas W. Johnson** director of engineering. He will be in charge of engineering of the company's five divisions, Kinney Mfg. Co., Aurora Pump Co., and the Dudco, Hydreco and Watertown divisions. Prior to his new appointment, Mr. Johnson was assistant to **John G. Wood**, who is the company's executive engineering consultant.

Mr. Johnson graduated from Newark College of Engineering with a B.S. degree in mechanical engineering. He received a degree in naval architecture from the Post Graduate School of the U. S. Naval

What does "S. B." mean to you?

To some, it means Strictly Business. To others, it means a "Secretary-Boss" relationship. But, to thousands who want smooth-running machinery, it means Small Balls . . . Small Balls by Universal . . . true-to-round, even when they are no larger than a mustard seed.

We make them up to 1" in diameter in chrome, stainless, bronze, solar, aluminum, and special materials. Customers say they are Sure Better.

Universal Ball co.

WILLOW GROVE
MONTGOMERY CO., PA.

"HOW MEYERCORD SERVES INDUSTRY"
No. 1 of a Series

MEYERCORD *Nameplate* DECALS Help You DESIGN Your Product

Here's a way to shave production costs starting in the blueprint stage . . . a complete and continuous service to you and everyone in your organization concerned with product development and merchandising.

Meyercord Nameplate Decals identify your product and instruct consumers in its use. We produce Meyercord Nameplate Decals for *any* commercial surface . . . for *any* temperature condition . . . for *any* production run, short or long. And we take over the design problem.

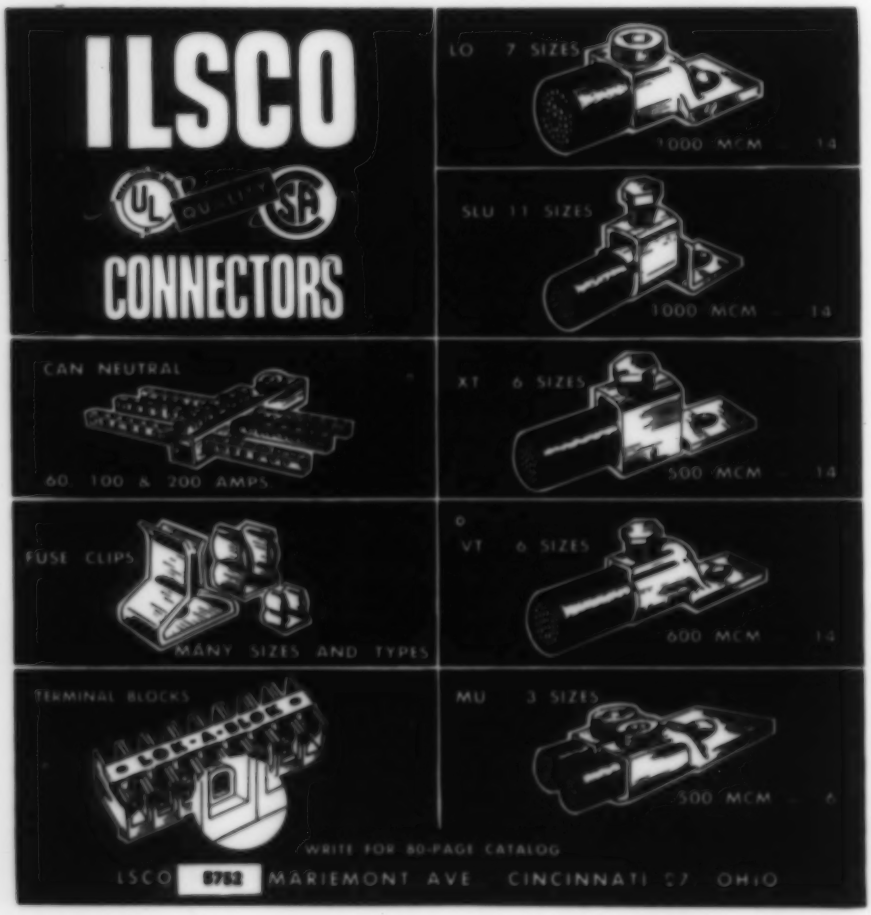
Your Meyercord representative will show how our decals surpass in ease and speed of application . . . with low unit cost. He'll show you how to cut time, labor, and material costs . . . and he'll place our laboratory at your service . . . without obligation.

FREE! "Mark-It" Manual of Decal Nameplates

Send today, on your company letterhead, for this valuable full-color guide to every industrial problem in marking, identification, instruction, and information.

THE MEYERCORD CO.
World's Largest Decalcomania Manufacturers

DEPT. E-311
5323 WEST LAKE ST.
CHICAGO 44, ILLINOIS



Men of Machines

Thomas W. Johnson

Academy, and he also holds an M.E. degree from Stevens Institute of Technology. He was associated with the Eclipse Pioneer Div. of Bendix Aviation Corp. for six years before joining the New York Air Brake Co.

Harold J. Holmes recently was named assistant to the vice president of engineering of Heald Machine Co., Worcester, Mass. Mr. Holmes formerly was chief engineer of Atlas Press Co., Kalamazoo, Mich.

Duff-Norton Mfg. Co., Pittsburgh, has announced the appointment of **John J. Dixon** as chief engineer. He joined the company in 1943 after serving in the engineering department of the Edwin L. Wiegand Co. Mr. Dixon succeeds **Frank H. Schwerin**, who is retiring after 36 years with Duff-Norton.

Promotion of **H. W. Cory** from assistant chief engineer to chief engineer of control engineering has been announced by the Hawley Works of Allis-Chalmers Mfg. Co., Milwaukee. Mr. Cory has been associated with control operations since joining the company in 1941. He succeeds **T. B. Montgomery**, who has been named chief engineer of Allis-Chalmers' new industry application section.

Men of Machines

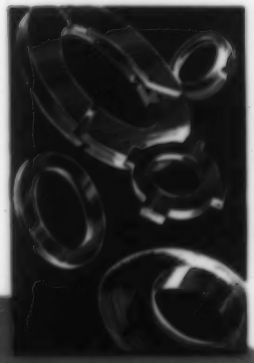
Frank T. Gifford has been appointed assistant chief engineer of the switchgear department of the Boston Works of Allis-Chalmers Mfg. Co. He succeeds **John F. Chipman,** who was named general manager of the Boston Works. Mr. Gifford joined the company in 1937 and has been engineer in charge of circuit breaker design since June 1954.

Marion Electrical Instrument Co., Manchester, N. H., has announced the appointment of **F. J. Gaffney** as vice president of engineering. He was director of engineering for the guided missiles division of Fairchild Engine and Airplane Co. In his new position, Mr. Gaffney will direct the development of industrial and aircraft instrumentation.

John W. Sawyer recently was named head civilian of the Gas Turbine Branch of the Bureau of Ships of the U. S. Navy. He was formerly assistant for research and development of the Steam Turbine and Gear Branch of the Bureau of Ships. Mr. Sawyer received a B.S. degree in electrical engineering from the North Carolina State College of the University of North Carolina in 1933 and a B.S. degree in mechanical engineering from Ohio State University in 1938. Active in the Washington, D. C.,

John W. Sawyer

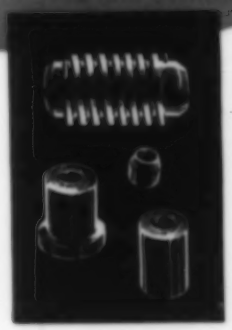
SOMETHING NEW IN MECHANICAL SHAFT SEALS



Late developments in Stackpole carbon-graphite shaft seals include oil seals that greatly minimize deterioration from pitting and blistering. Other types are designed for use with air, gases, corrosive chemicals and other liquids. Send details of your application for recommendation and samples.

STACKPOLE Carbon-Graphite

EASY SOLUTIONS TO MANY MOLD and DIE PROBLEMS



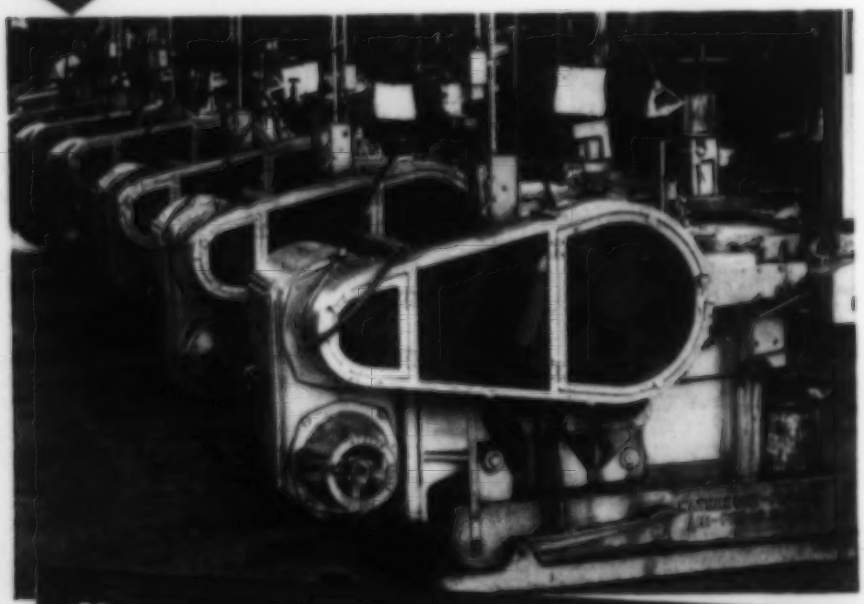
In foundry work, for instance, the high heat capacity of carbon molds or dies makes them ideal as chill materials. In powder metallurgy, they maintain strength under pressure at high temperatures. In other cases, as in rail bonding, the simplicity of forming or machining accurate molds or dies lends itself to real economy.

LONGER BEARING LIFE UNDER TOUGH CONDITIONS

The use of self-lubricating carbon-graphite bearings holds interesting possibilities for a great deal of modern equipment. Units can be molded inexpensively to desired shapes and close tolerances. Composition of the bearings can be adjusted for maximum life and lubricating efficiency for specific uses.

STACKPOLE CARBON COMPANY
ST. MARYS, PA.

REEVES Vari-Speed Motodrives provide the exact speeds required for maximum production and efficiency on this bank of six Waterbury-Farrel cold heading machine installation in the P. R. Mallory plant in Indianapolis.



Your machines will produce more at less cost with—

REEVES
Variable Speed Control

● Whether your production problems involve manual or *automatic operation* . . . REEVES complete line of Variable Speed Drives and Controls will deliver the exact speed required for each operation, each operator, under every changing condition of method or material. REEVES Speed Control is positive and accurate to a fraction of an RPM.

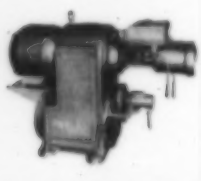
Let a REEVES Speed Control Engineer show you how you can make your machines . . . your operations . . . more efficient, more economical, more profitable—*now!* Write today for complete details. Specify H16-L.

***Only* REEVES offers you a complete line of Variable Speed Drives and Automatic Controls!**

MOTODRIVE combines motor, speed varying mechanism and reduction gears in single, compact unit. Speed variations 2:1 to 6:1. Sizes to 40 hp. Also available in fractional sizes with 10:1 ratio.

VARI-SPEED MOTOR PULLEY converts any constant speed motor to an accurate, variable speed drive with 4:1 ratio. Rugged, dependable—Sizes to 15 hp. VARI-SPEED JR. available for light machinery.

VARIABLE SPEED TRANSMISSION for providing infinite, accurate speed flexibility over a wide range—2:1 to 16:1. Especially adaptable for heavy duty application. Fractional to 87 hp.



AUTO-PNEUMATIC CONTROL with linear output speeds is but one of a complete line of automatic controls designed and engineered to operate your machines more efficiently, more profitably, automatically.

REEVES PULLEY COMPANY • COLUMBUS, INDIANA

Men of Machines

section of the American Society of Mechanical Engineers, Mr. Sawyer was chairman of the section in 1953-1954. He is also a member of the American Society of Naval Engineers, Society of Naval Architects and Marine Engineers, U. S. Naval Institute, Association of Senior Engineers of the Bureau of Ships and is a registered professional engineer in the District of Columbia. Mr. Sawyer has been granted several patents, and he is the author or co-author of a number of technical papers, including several which have appeared in MACHINE DESIGN.

Hjalmar A. Anderson was recently appointed chief project engineer of Lindberg Industrial Corp., Chicago. Mr. Anderson was assistant chief engineer of the industrial furnace division of Sunbeam Corp.

John K. Morris has been promoted to manager of engineering of the six plants operated by Western Gear Works, Lynwood, Calif. He has been associated with the company for 20 years and was previously supervisor of design engineering in the Lynwood plant. **Louis L. Acurso** was promoted to supervisor of design engineering for the Lynwood plant, and **Richard Hoard**, to general supervisor of project engineering for all plants.

Cleveland Crane & Engineering Co., Wickliffe, O., has announced the promotion of **Harry Cotesworth** to chief engineer of the development department and **Kurt R. Weise** to chief engineer of the Cleveland Tramrail Div.

Franklin E. Lowance has been appointed to the newly created position of director of research and engineering for Westinghouse Air Brake Co., Wilmerding, Pa. He will direct the company's program and co-ordinate the research and engineering activities of all its subsidiaries and divisions. Dr. Lowance received his Ph.D. degree in 1935 from Duke University. He has served as head of the depart-

Franklin E. Lowance

ment of physics and engineering at Centenary College in Louisiana and was on the staff of the Georgia Institute of Technology for seven years. During World War II he served as a civilian with the Office of Scientific Research and Development. In August 1953 he was named associate technical director at the U. S. Naval Ordnance Test Station at China Lake, Calif.

Fred W. Arndt recently was appointed chief engineer of Heil Process Equipment Corp., Cleveland.

Formerly chief engineer and a director, **Carl J. Oxford** has been elected vice president in charge of engineering of National Twist Drill & Tool Co., Rochester, Mich.

Charles F. McElwain has been appointed director of defense engineering and defense manufacturing for International Business Machines Corp., New York.

Ford Motor Co., Dearborn, Mich., has appointed **V. Y. Tallberg** executive assistant to the vice president of engineering and **George E. Altmansberger** director of engineering administration.

Howard D. Tindall has been appointed manager of the Transformer Div. of Federal Pacific Electric Co., Newark, N. J.

SILICONE

REMAINS RESILIENT

-100°F +500°F

RUBBER PARTS

With new compounds being developed almost weekly by manufacturers of basic polymers, today's Silicone rubber molded parts are performing faultlessly in vital applications where Silicone of less than a year ago could not be considered.

Remaining resilient at extreme temperatures (−100°F to +500F°) today's Silicone stocks have greatly increased tensile strength, far better compression set results, and bther vastly improved properties such as — excellent stability after long exposure to ultra-violet rays, prolonged weathering, fungus growth, many oils and a variety of chemicals. They also have excellent dielectic properties and water repellency. They bond well to metal, and are stainless and odorless.

Acushnet's Silicone rubber seals, gaskets, "O" rings, packings, diaphragms and numerous other parts are custom engineered to meet the toughest specifications.

Acushnet PROCESS COMPANY

Send for the Acushnet Rubber Handbook, a comprehensive rubber data reference.

Address all communications to 762 Belleville Ave., New Bedford, Mass.

Question about tubing?

ask your Rochester Products
Sales Engineer about
GM STEEL TUBING

GM STEEL TUBING BY ROCHESTER PRODUCTS, DIVISION OF GENERAL MOTORS, ROCHESTER, N.Y.

What's My Line?

WE don't recall ever seeing an engineer on the popular TV panel show *What's My Line?* But we sometimes wonder whether an engineer's answers to the panelists' stock questions would establish him as a professional man in the popular sense.

Consider these typical questions: Are you self-employed? Do you work for a profit-making organization? Do you deal in services? Do people come to you? Do you wear a uniform? Is there a product involved?

Answers to these questions for the well-established professions such as medicine, law, theology and education reveal striking similarities. But for an engineer employed in industry the pattern is notably different. Except that all professional people deal in services, there appears on the surface to be no common ground that the general public — as represented by a TV panel — would recognize.

The doctor, lawyer, clergyman and teacher either are self-employed, or work for nonprofit-making organizations. All deal directly and personally with the public and possess some kind of "uniform" symbolic of their profession — the surgical gown or the judicial, pulpit and academic robes. None are involved with a product.

Attributes of a profession that professional men themselves recognize are notably absent from the foregoing questions. If this is typical of the public's awareness of what constitutes a profession, some of our difficulties in achieving professional recognition become understandable.

Perhaps panelists and others wishing to establish professional status of a "contestant" should consider such questions as: Does your work satisfy an indispensable human need? Are the knowledge and skills which you practice common possessions of the general public? Must you in your work exercise discretion and judgment not subject to standardization? Do you belong to an organization for disseminating professional knowledge and promoting professional ideals? Do you need formal admission such as a license or ordination to perform your services?

Such criteria of professionalism are entirely compatible with typical employment conditions of engineers in industry. A few faint-hearted, shortsighted engineers, mistaking the shadow for the substance, seem ready to believe otherwise. In their zeal to rectify "working conditions" engineers should not overlook the continuing need to practice and promote, vigorously, the true standards and ideals of the profession. If we don't, nobody else will.

Colin Carmichael

EDITOR

Designing Special Machines

A recommended development procedure for designing machines for in-plant use

By Alex Brunner
Development Supervisor
E. I. du Pont de Nemours & Co.
Augusta, Ga.

DESIGNING of special machines, particularly for in-plant use, requires a somewhat different approach than designing devices that will be mass produced. Usually, a special machine is designed to fulfill one specific need in a manufacturing process. As such, just a very few may be constructed, or perhaps only one may be needed.

Several differences in the approach to the design and construction of such a machine immediately become apparent. One difference to consider is that the cost will be written off in what the machine does for its users and not in its sales. Another difference is the elimination of the necessity for tooling for production. Assembly-line setup studies and material-processing scheduling are also eliminated.

Personal contact with the entire development project is required of the engineer concerned with designing special machines. Often he guides it from its conception to its actual operation on the production line. An analysis of a typical development project illustrates the broad scope of activities with which the designer must concern himself.

Project Analysis: Just as the basic qualities required of a development engineer are the same whether he is to develop equipment for nuclear energy or automatic machinery to produce cylinder blocks for automobiles, so the basic aspects of all development projects are identical. They are:

1. The idea
2. Selling the idea
3. Design
4. Fabrication
5. Start up
6. Clean up

For every one of these steps, knowing successful techniques will help the engineer to do a better job.

The Idea: Many successful engineers have developed techniques for assimilating all there is to know about the problem at hand. About the most important one is to establish clear specifications in writing, outlining the expected performance of the machine. While establishing specifications, become as familiar as possible with the operations preceding and following the machine in question. A flow sheet of the operations will make many of the specifications and requirements much more understandable. In addition, be certain not to overlook the possibility of combining operations if that would lead to more economical production.

While preparing the flow sheets, labor and material requirements must be considered—as well as desired production rates and schedules. Also to be considered are the physical conditions under which the production operations are to be performed. Among these are building space, cleanliness, and quality of operating personnel.

Preparing the flow sheet offers an excellent opportunity to discuss the process and the machine with many people. No source of information should be overlooked. Advice from machine operators, area supervision, plant technical organizations, and the plant and departmental research groups should be sought. Not only can the ideas these groups have to advance be valuable, but asking their opinions gives them the feeling that they have a stake in the equipment and its success because their ideas were considered in formulating the basic concepts.

A word of warning is necessary at this point. In getting all of the information on how things have been done in the past, avoid the prejudices and "witchcraft" which have accumulated over the years. Many successful machines have required redesign of a product, which at first glance seemed impossible to those who had handled it for many years. Often the redesign involves the use of processes completely unfamiliar to the operating people. In studying a problem, the engineer must be sure to exhaust all possibilities of simplifying the process or the product by changes in materials, in operations, or the combining of operations.

In developing tentative design ideas, it is well to break down the machine into its essential units. It will be easier to develop parts of the machine and then combine them into a whole rather than try to develop everything at the same time. Usually the first approach to a solution is rather complicated, and for every function of the equipment a separate mechanism is designed. The real creative development work starts when all these complicated mechanisms are finally simplified, condensed, combined, and made practical.

These ideas should be discussed with fellow workers, supervisors, or customers. Even ideas which have not been fully developed should be discussed because in the formative stages, the advice of experienced people can be of most benefit. Very often a casual question will suggest a new and better solution. During this process of formulating the basic idea, always think back to the fundamentals of the process and ask "why" whenever an idea has to be rejected. Very often it will help immeasurably in finding a new and different approach if the reason why the one to be rejected did not prove satisfactory is clear.

Selling the Idea: Most often the idea is sold in meetings. Three important items will influence the outcome of the meeting. They are: (1) the presence of the right people, (2) good presentation, and (3) enthusiasm for the idea.

Presence of the right people is essential because a meeting is only a waste of time unless people who can make decisions are present. At the end of the

8 Steps

to successful design of special machines

1. **Gather as many facts, ideas and opinions as possible about the product and the equipment. Absorb them by incorporating them into notes and diaries, sketches and calculations.**
2. **Digest all this information thoroughly. Establish machine specifications and list the ideas that occur about ways of doing the job. Analyze them and list the advantages and disadvantages of each.**
3. **Decide on a plan of attack and formulate basic recommendations.**
4. **Sell the idea by effective presentation to the people who can make the decisions.**
5. **In executing the idea during the development and design phase, make certain that all the knowledge needed to do the best possible job is brought to bear.**
6. **During fabrication of the machine, maintain close contact with the shop to learn how to make the next machine a better one, to acquaint the mechanics with the design intent, and to benefit by their suggestions.**
7. **In trying to get the machine into operation, be persistent and thorough in finding and eliminating all of the little defects which prevent the machine from functioning the way it should.**
8. **Bring the job to an orderly conclusion by providing the necessary revised drawings, operating and maintenance manuals, and accounting for funds and activities.**

. . . about the most important technique is to establish clear specifications in writing, outlining the expected performance of the machine...

meeting the man presenting his ideas must leave with a clear understanding of his next step—either corrections to make these ideas acceptable, a new approach based on clearly defined objections, or acceptance of the idea and instructions to go ahead with the design.

For the best possible presentation, visual aids, charts, models, or mockups of the equipment are helpful. The presentation should be detailed enough so that a person not completely familiar with the engineering details of the job can understand it, but should not go into so much detail that the person who is familiar becomes bored. If the engineer can prove in any way that his idea is sound by using test models or mockups, it will help him immeasurably during the meeting.

In presenting his ideas, the engineer should make a definite proposal and expect the group to come up with definite recommendations. A meeting is usually a poor place to weigh the advantages and disadvantages of ideas. Too many people are present who do not have all the necessary facts at their disposal. The best presentation will consist of submitting a proposal and backing it up with the reasoning and proofs that have gone into the selection of this alternative.

Enthusiasm for the idea is important in the presentation. The engineer must be enthusiastic about his own idea, but he must not be carried away by it to a point where he will go beyond what he can back up with facts. Nothing can be more damaging than if it can be shown during the meeting that the facts the engineer is presenting are not completely reliable. Also, he must not give the impression that he is so convinced that his idea is the only possible one that he will not listen to objections. On the contrary, he must be alert to reactions from his listeners and receptive to their suggestions or criticism.

At the conclusion of a meeting, the results should always be summarized in minutes and circulated to those in attendance and others interested in the problem. These minutes will be invaluable to show what has been discussed and what has been agreed upon. They will also show up any misunderstandings that may exist. After the usual reviews and discussions of the basic facts, of the conclusions drawn from them, and of the proposals prepared, the idea will presmuably have been sold The next phase, comprising the actual design and development of the equipment, follows.

Design: During the design and development of a special machine, knowledge becomes the most important quality of a development engineer. With the complexity of present-day machines, which in many cases involve mechanical movements, electromechanical controls, and hydraulic power sources, no one man has sufficient knowledge for all the phases and aspects of machine development. One of the most important characteristics of a good development engineer is that he realizes his own limitations and is always willing to go to the sources of additional knowledge in order to apply the best available talents to his project.

Some very basic decisions have to be made at the start of the design, and many of them require a reconsideration of the early decisions which led to the basic idea of the machine. Based on the first layouts, decisions will have to be made whether to use purely mechanical means, hydraulic or pneumatic systems or electrical or electronic controls. Effects on design of operating conditions will have to be considered—conditions such as exposure to corrosive atmosphere, possible contamination of lubricants, whether the machine will be expected to stand up under continuous service or will be used only intermittently, and how accessible it will be for maintenance. Hazards to the operator resulting from the product the machine will handle will have to be considered, and also possible hazards from the mechanism and the equipment itself. The design phase is the best time to consider any plant safety requirements. As the layouts of the machine take shape, timing diagrams which show the correlation of the different basic units must be prepared. As the design is continued, it should be compared with the previously established specifications again and again to be sure that the original design intent is still being followed.

To make the machine as economical as possible, commercial parts should be used where feasible. The design should be continuously evaluated for simplification, combining of functions; and reduction of cost through use of maximum allowable

tolerances, minimum finish specifications for machine parts, design simplicity, and proper dimensioning to assist in machining. An effective technique for this purpose is the preparation of check lists, listing all the points which are to be considered.

After the layout of the machine and its basic assemblies have reached the point where detailing can be started effectively, detailed design of the most complicated pieces should be begun. Usually, development of the larger details will point up many items in the basic design which require modification.

Seldom are experimental equipment or special machines built from drawings which are checked in every detail. In many cases, where only one machine is needed, it is more economical to check only the most important dimensions and to correct minor mistakes in the drawings as they are discovered in the shop. Consequently, in order to have detailers in a mechanical development group who have the high qualities required, it seems desirable to use detailing as a training phase for the development engineer.

Fabrication: The best time to start fabrication of equipment is when a complete, checked set of drawings can be released to the shop or to an outside manufacturer. However, the pressure is often strong to cut corners in order to have the machine available at the earliest possible moment. Then the shop may find itself starting the construction of a piece of equipment with incomplete drawings.

Closest co-ordination between the design group and the shop is needed in such a case. But many additional benefits can be obtained on any project from close contact between the groups. First of all, the development engineer or designer will gain additional knowledge about the effect of design on the fabrication of parts and the assembly. Often this additional knowledge can be applied to the construction of the machine under development. During fabrication a clear record of all authorized changes should be kept, so that the drawings can be revised at the end of the job.

Engineers should establish an atmosphere of confidence and mutual respect between the men who design the machines and the men who have to manufacture them. After having witnessed the fabrication of a machine, any designer will certainly come away with a much greater appreciation for the burden and expense he imposes with every tight dimensional tolerance, and every highly finished surface.

Start Up: Every development job is approached with the same hope—that this machine will work from the moment that the button is first pushed. Almost always something shows up that was not considered. A clearance may not be quite right.

. . . these ideas should be discussed with fellow workers, supervisors . . . because in the formative stages the advice of experienced people can be of the most benefit . . .

. . . engineers should make it a practice to visit the shop regularly during construction, and should establish an atmosphere of confidence and mutual respect between the men who design the machines and the men who manufacture them . . .

or the materials selected may not work together as well as has been hoped, or the timing may be off, or acceleration and deceleration may not have been taken into consideration sufficiently. One small item may delay the startup of an otherwise well-designed machine, and "debugging" is necessary. After an engineer has spent time starting up equipment, he will have learned how thorough he has to be in his designs. It is much cheaper and faster to improve machines on the board than in the shop.

It is important to know when to stop the "debugging" process and put the machine in initial, limited operation in the plant. If good relationships have been established with production men, machine operators, and the maintenance group, they will be on the design group's side, trying to find and eliminate the last few trouble spots, which can only be found when the machine is in service. During the first days of operation, the engineer should spend practically all his time at the machine. There he can observe the difficulties as they are encountered, and can analyze the source of the trouble before corrective action has been taken.

Clean Up: To properly finish the job a complete and usable set of records should be compiled for the use of the group operating the machine. These records may include a set of drawings incorporating all of the changes found necessary during fabrication and start up, operating and maintenance manuals and a complete list of spare parts to be carried by the maintenance shops.

In many cases, some sort of report must be written on the work done under the project. Findings of important studies should also be summarized. These studies may have covered investigations on tooling, materials substitution or similar items, and results might be useful in other applications.

Finally, an accounting is visually made of the expenditures for the development. The proper portion of the expenditure has to be capitalized and the funds spent on abandoned designs, or testing and development work which cannot be properly charged to the machine, have to be closed out to the proper codes. And, unfortunately too often, an accounting has to be given why the machine has cost more than had originally been anticipated.

And now, a last word about the development engineer. He will make a success in a very satisfactory field if he has intense curiosity about what makes things tick, and if he has enthusiasm and a deep interest in his work. He must prove in every job, no matter how small and insignificant, that he can do an outstanding job. As he solves the smaller problems in machine development, the larger problems will come his way. Increased monetary compensation will not be the only reward. Other gains include progress in his profession and the immense satisfaction of seeing his idea transformed into an actual machine.

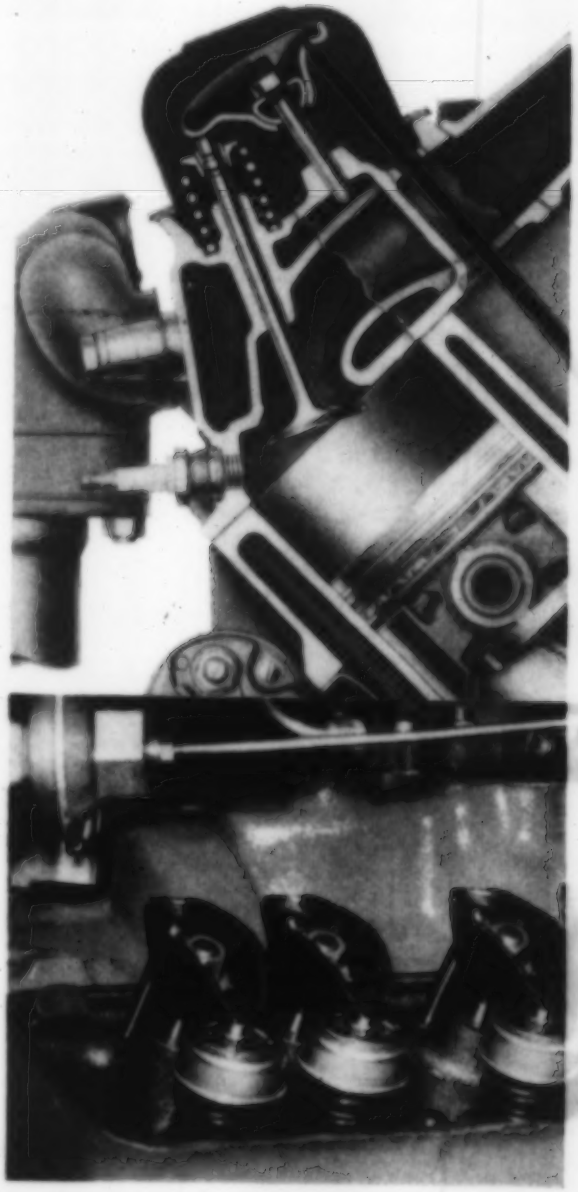
They Say . . .

"The development of a research project is like the growth of a tree. It begins in a certain direction, but the new things found soon lead to other new things in other directions and so the branches spread out. But we don't want only branches and leaves in all directions; we usually want to reach certain general or specific objectives. So we must prune the unwanted branches to get fruit where we want it, to pay for cultivating the tree. The economic aspects must always be kept in mind, in industrial research."—HANS ERNST, *director of research, Cincinnati Milling Machine Co.*

"A problem of major importance in obtaining and retaining qualified civilian personnel for (government work) is the current salary scale for technical personnel in research and development work. Private industry, in many cases, can pay twice or more the salary to technical personnel for the same type of work. In addition, the government work is often considered to serve as training for higher positions in private industry involving similar work on a contractural basis for the government.

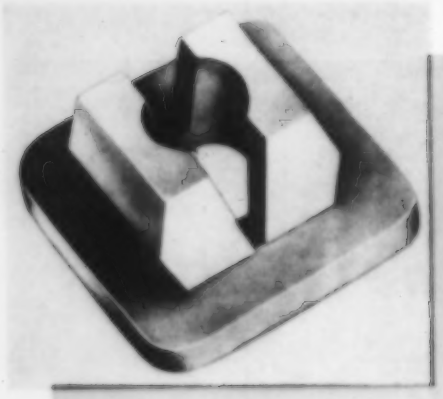
Witnesses before a Congressional committee have testified that usually a salary increase of approximately 50 per cent is sufficient to attract scientific and technical personnel away from government research and development positions."—MAJOR GENERAL CREASY, *head of research and engineering, Army Chemical Center.*

SCANNING the field for IDEAS



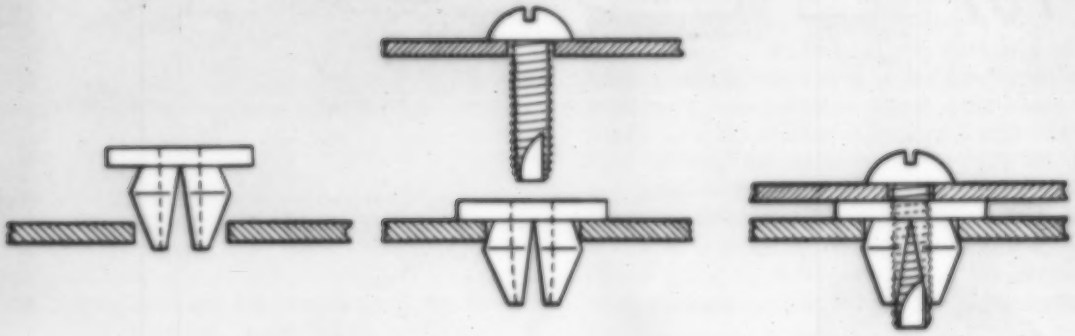
STAMPED BALL-PIVOT rocker arms simplify valve train assembling and servicing of 1955 Chevrolet and Pontiac engines. Misalignment tendencies, such as valve cocking, and stem wear are minimized by the unique ball-pivot design, and the rocker arms are entirely independent of each other. Made of case-hardened steel, each rocker arm is a precision stamping with an oval-shaped hole pierced in the bottom. The rocker arm stamping, mounted on a press-fitted stud, is retained by a fulcrum ball and lock nut.

In the Chevrolet engine shown, oil fed through the push rods lubricates both the ends of the push rods and the ball pivots. Oil under pressure in the push rod of the Pontiac engine lubricates only the push rod ends while the ball pivots are pressure oiled through the drilled gallery-fed stud supports.



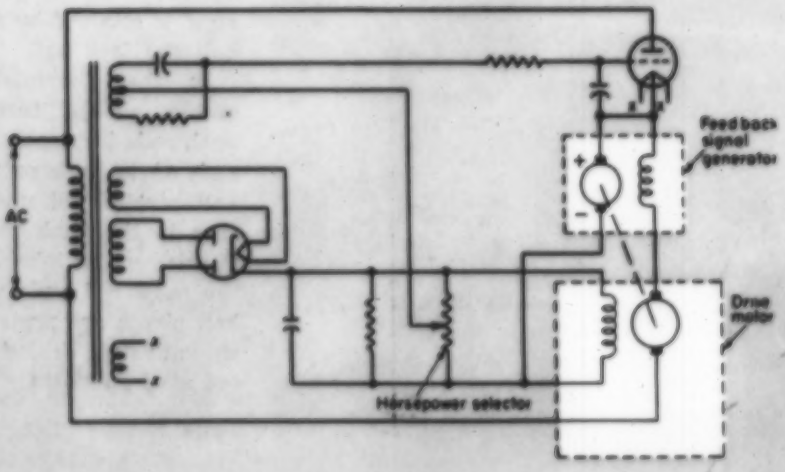
PLASTIC SNAP NUT design reduces multiple parts as well as assembly costs and time by serving as a combination grommet, nut and spacer washer. Developed by Shakeproof, division of Illinois Tool Works, the nylon blind-screw receptacle snaps into position under finger pressure. A self-tapping screw cuts threads into the plastic grommet. This assembly procedure spreads the legs of the unit and thereby firmly locks it in place.

The plastic characteristics of the part make it noncorrosive and noncrazing, eliminate danger of chipping surface finishes, and permit it to serve as an electrical insulator.



CONSTANT OUTPUT HORSEPOWER from an electronic drive is automatically assured by a novel control circuit developed by Servospeed, a division of Electro Devices Inc. For a power-sensing device, this circuit employs a small dc signal generator that is specially designed and uniquely connected to produce an output voltage directly proportional to the dc motor output power. This generator voltage, used as a feedback signal and matched against a reference voltage, is employed to control the drive motor field excitation to provide constant output power.

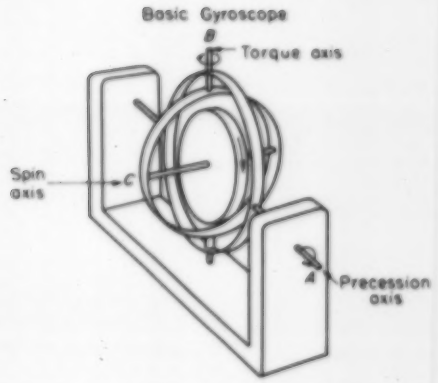
Neglecting losses, dc motor developed power in watts equals countervoltage (cemf) in volts times armature current in amperes. Since the drive motor and signal generator are mechanically coupled, the generated voltage in each increase and decrease together and in a direct relation to rotational speed. With constant field excitation, torque of a dc motor varies directly with armature current. Thus, by exciting the signal generator field with the motor armature current, the generator output voltage is directly proportional to the developed power of the motor.

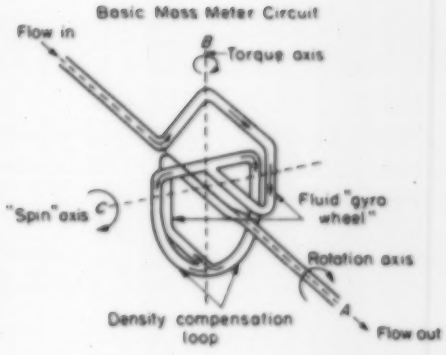


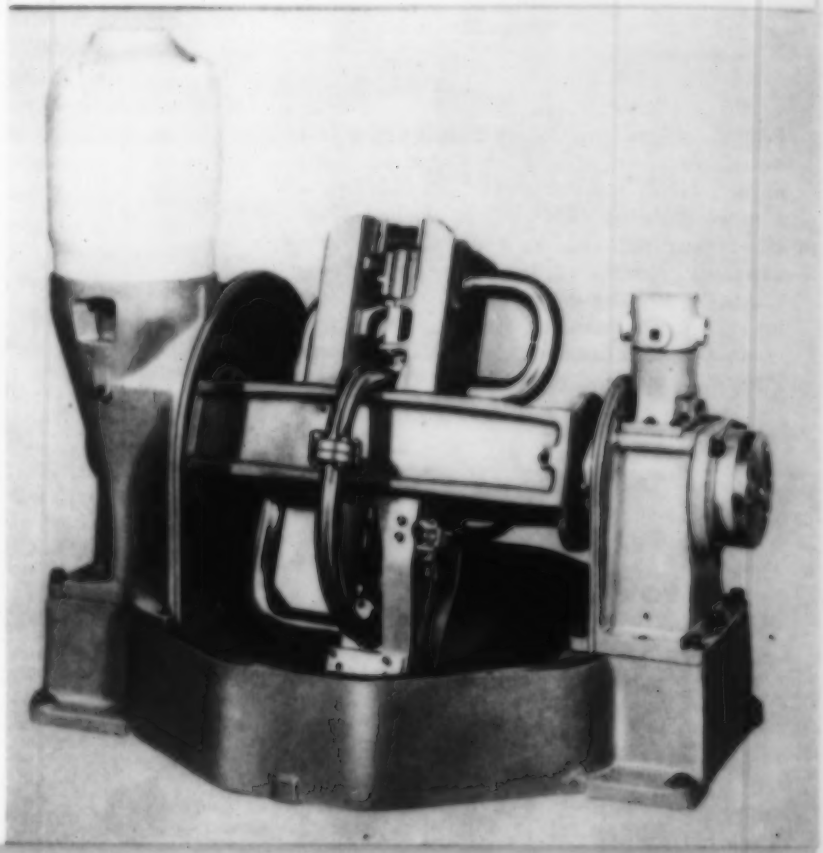
IDEAS

FLUID "GYRO WHEEL" utilized in the design of a flow meter offers a practical, reliable method of precision metering of flowing liquids or liquid-gas mixtures. Developed by Norwood Control Engineering Corp., this gyro mass meter employs design principles whereby meter accuracy is fundamentally independent of fluid temperature, pressure, viscosity or volumetric flow rate.

In operation the measuring assembly is rotated at a constant speed about axis *A*. This rotation corresponds to forced precession of a gyroscope assembly about axis *A*. Under these conditions the central ring of a gyroscope will produce a torque about axis *B* when the gyro wheel is spinning about axis *C*. The magnitude of the *B*-axis torque depends on the *A*-axis rotation rate and the angular momentum of the gyro wheel about axis *C*. Thus to measure mass flow of a fluid, the flowing stream is guided through a pipe of suitable shape so that the mass of material flowing simulates the effects of a rotating gyro wheel. Since rotation about axis *A* is held constant, torque developed about axis *B* is directly proportional to the mass flow rate through the pipe. This torque deflects the measuring assembly through a small angle which is accurately measured by an electromagnetic rotary transducer connected to a rate indicating meter.







Factors in selecting and applying

Fractional-Horsepower

By Fred L. Olson
Motor Application Engineer
Bodine Electric Co.
Chicago, Ill.

MATCHING a fractional-horsepower motor to a specific application is influenced by many factors. The best answer is usually easily determined if requirements of the design are compared with the attributes available in small motors. Most of the pertient criteria are listed at the head of this article.

First Considerations: A process for selecting a fractional-horsepower motor is, first, to determine answers to a number of elemental questions. Then, the characteristics of available motor types might next be surveyed. Finally, all the pertinent application requirements are brought into balance with the characteristics or possible features of fractional-horsepower motors.

Anticipated annual sale of the machine on which the motor is applied is a factor to be considered early; quantity may dictate whether a standard motor is mandatory or whether the volume will support the added cost of a special motor. Often, relatively simple mechanical modifications, such as special shaft or special mounting, can be made in otherwise standard models without severely penalizing cost. However, if small or infrequent orders are anticipated, economy suggests selection of a standard motor or reducer from the many types regularly available from stock. If the decision turns toward a special motor, quantity is important from the standpoint of influencing motor production processes. For example, special castings may be necessary, and quantity may be the deciding factor between, say, sand or die casting.

Appearance may be a factor, particularly in instruments, appliances, medical equipment, etc.,

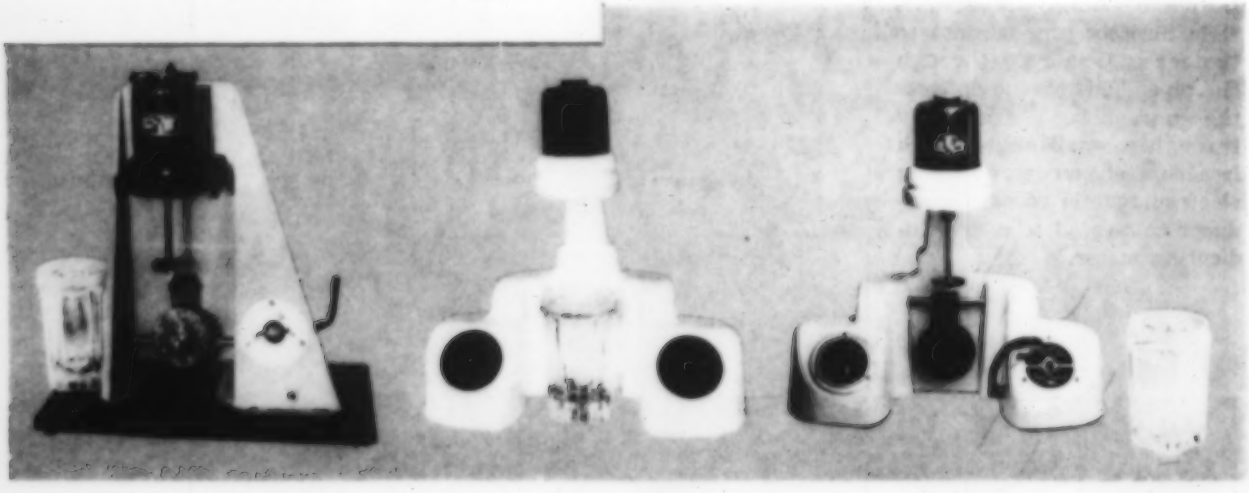


Fig. 1—Stages in the development of a fractional-horsepower motor application. Initial model, (left) served to test the function of a new solubility index mixer design. Overall appearance design evolved from clay mock-up studies (center). Final design (right) utilized a synchronous motor: 1/75-hp, 115 v, 60-cycles, single-phase, 3600 rpm, ventilated, ball bearings, resiliently mounted. Photos, courtesy Central Scientific Co.

Motors

1. Production quantity
2. Appearance
3. Size or weight
4. Load
5. Power supply
6. Speed—constant or adjustable
7. Duty cycle—continuous or intermittent
8. Mounting and shaft position
9. Quiet operation
10. Bearings—sleeve or ball
11. Thrust—radial and/or axial
12. Coupling to load
13. Atmosphere—humid, salty, explosive
14. Ambient temperature range

where eye appeal strongly influences sales, *Fig.* 1. Shape and finish of the motor may require special attention, or motor parts might even be built-in to aid styling or design of the unit for convenience.

Size or weight may be critical in portable or miniature equipment, for example. Certain measures can be taken with selection of standard motors or development of special types to insure best results. Improved ventilation, better insulation and lubricants, higher operating speeds are all possibilities in this direction.

Expected power source is, of course, a primary factor. Is direct current available? What voltage? If alternating current will be the source, what is the voltage, number of phases and frequency? Or, is operation on either ac or dc required?

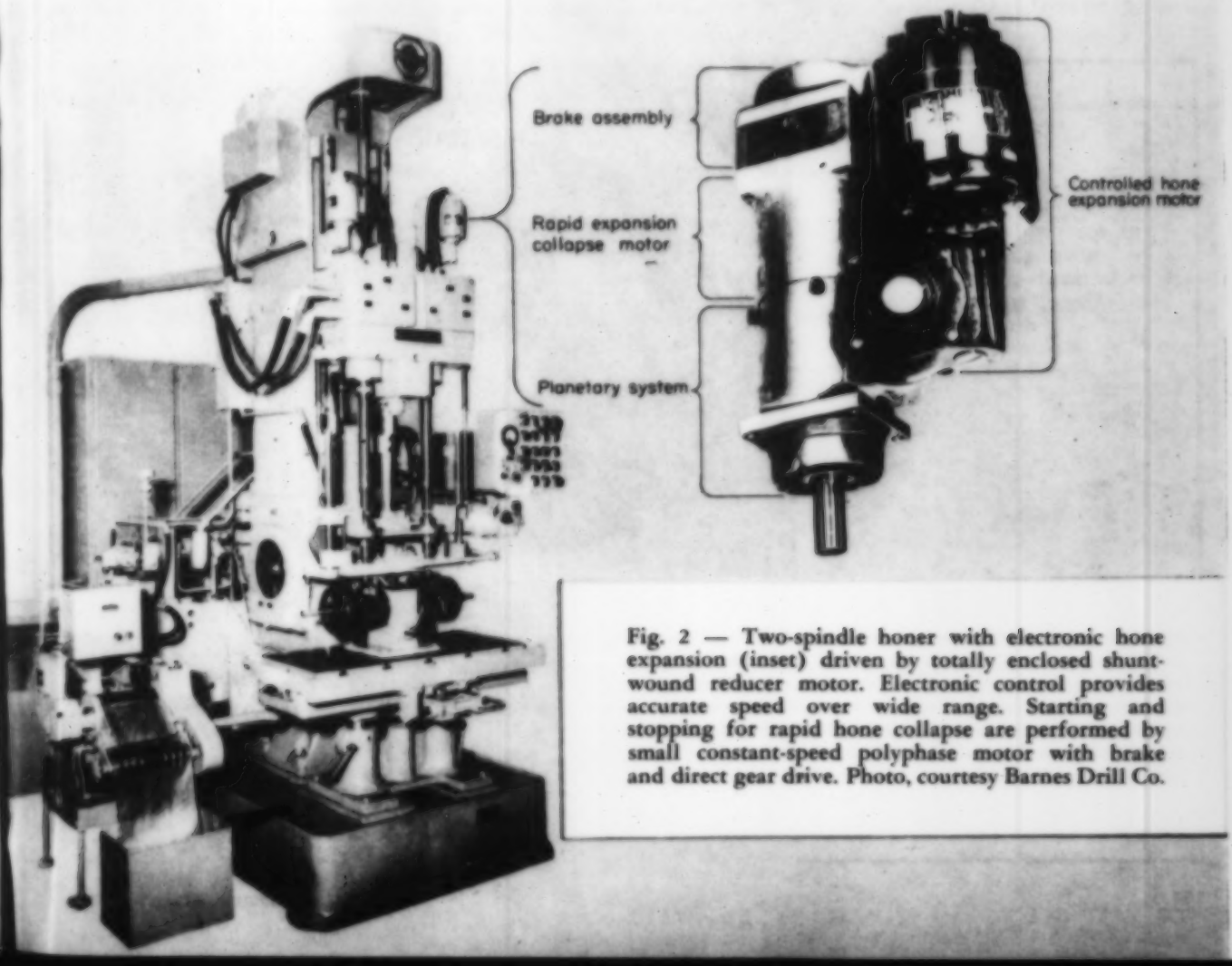


Fig. 2 — Two-spindle honer with electronic hone expansion (inset) driven by totally enclosed shunt-wound reducer motor. Electronic control provides accurate speed over wide range. Starting and stopping for rapid hone collapse are performed by small constant-speed polyphase motor with brake and direct gear drive. Photo, courtesy Barnes Drill Co.

Voltage fluctuation range likely to be encountered during service has a bearing upon motor selection or design. Speeds of all motors, except synchronous types are affected to a degree by normal voltage fluctuation. Even synchronous motors have a minimum voltage limit with respect to "pulling in" the load.

Speed and direction of rotation are quite pertinent in the study for the best type of motor. Also, to what extent is a departure above and below rated speed permitted? Most timers for example, are critical in this respect and require the exact speed supplied by a synchronous motor. Other applications may require a certain minimum speed at given voltage and load.

Adjustable speed duty, if required, may play an important role in terms of motor choice. Must the motor provide stepless speed adjustment over a certain range? Or, are several fixed speeds needed? For a dc source, speed range may influence choice of either a series-wound or shunt-wound motor. Expected running at a certain speed most of the time is worth noting because of the possible effect upon design for brush life. *Fig.* 2 shows a dc reducer motor application with electronic speed adjustment.

Motor Types: If the prior factors have been considered in a given design, a logical point has been reached for beginning to narrow the choice to a specific motor type. Commonly available types are reviewed briefly here to help in that choice. Basic motor types and their characteristics are summarized in *Table* 1 and criteria for typical applications in *Table* 2.

Speed characteristics of the various motor types are quite different. Standard horsepower ratings of ac induction and dc motors are made at 3450, 1725, 1140 and 850 rpm on 60-cycle power, and at about 5/6 of these speeds when rated for 50-cycle operation. Alternating-current induction motors inherently run at more nearly constant speed than other types. In general, except for some special shaded-pole and capacitor-winding types, they are not generally suitable for adjustable speed.

Speed of the universal series-wound motor may be as high as 10,000 or 15,000 rpm; its speed, however, is quite sensitive to load. The universal motor operates on either alternating or direct current but usually develops more power on direct current. Universal motors (series-governor) are widely used on projectors and office machines, *Fig.* 3, and similar products.

Shunt or compound-wound direct-current motors operate at a relatively constant speed. Speed of these motors can be varied by inserting resistance in the armature and/or field circuit just as with series (universal) motors which, however, have somewhat wider speed range.

Synchronous motors are generally supplied at 1800 or 3600 rpm for timing applications where exact speed is important. Their speed is not affected by normal voltage fluctuations, if properly applied. Careful testing of the application is es-

Fig. 3—Check protector with cover removed to show series-wound motor drive. Photo, courtesy Hedman Co.

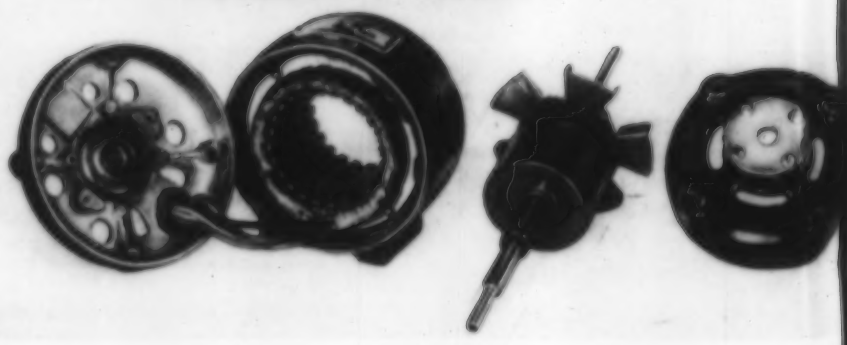


Fig. 4 — Hysteresis type of synchronous capacitor motor

sential, especially where high inertia or peak loads must be accelerated. The special hysteresis synchronous motor, *Fig.* 4, pulls higher inertia loads into synchronism.

Permanent-split capacitor motors are quiet operating due to their symmetrical winding, require no internal starting switch like split-phase motors, and have low starting torque but high breakdown torque. A dependable oil-filled capacitor is permanently connected in series with the capacitor circuit winding. This type is becoming increasingly popular on air conditioners, especially where more than one speed setting is required. Their low maintenance and dependable performance make them ideal for some office machine applications, *Fig.* 5. Frequent starting or reversals can be met, too. Where unusually high starting and breakdown torques are demanded, a two-value capacitor motor is best but also more costly.

Reversing of general purpose split-phase or capacitor-start motors is usually possible at rest only, due to the starting switch action. However, in ⅛-hp and up some of these types are available with special instant-reversing switches.

Instantaneous-reversible motors are built by some manufacturers of fractional-horsepower motors in permanent-split capacitor, synchronous capacitor, series, shunt or compound (for dc) and polyphase types. The first three single phase motors mentioned can be provided with either three leads for reversing with a single-pole, double-throw switch, or four leads for reversing by a double-pole, double-throw switch. Instant reversing is desirable on many cycling operations and can eliminate costly mechanical means within the limits of the

Table 1—Motor Characteristics

Characteristic	AC Motors								DC Motors	Universal Motors (ac-dc)	
	Split-Phase	Poly-phase	Syn-chronous Split-Phase	Syn-chronous Polyphase	Syn-chronous Capacitor	Shaded Pole	Permanent Split-Capacitor	Capacitor Start	Shunt or Compound	Series	Series-Governor
Duty											
Continuous	X	X	X	X	X	X	X	X	X		
Intermittent										X	X
Rotation											
Unidirectional						X				X	X
Reversible at rest only	X		X					X			
Reversible at rest or during rotation		X		X	**X	**X	X		X	**X	**X
Speed											
Constant, fixed	X	X	X	X	X	X	X	X			
Constant, adjustable									X		X
Variable										X	
Starting Torque											
Low					X	X	X				
Normal	X		X						X	*X	
High		X		X				X			X
Starting Current											
Low					X	X	X				
Normal	X	X	X	X				†X	X	X	X

*Starting torque high for series motors with normal speed ratings of 7500 rpm or more.
†Starting current appreciably lower than for split-phase motors.
**Reversible during rotation in some cases.

Table 2—Principal Operating Criteria of Typical Applications

Application	Small Size or Weight	Gear Reduction	Speed Constant	Speed Adjustable	Starting Torque Normal	Starting Torque High	Frequent Reversal	Frame Open	Frame Encl.	Quiet Operation
Air Conditioners			X	X	X				X	X
Arc lamps	X	X		X		X		X		
Automatic phonographs	X		X		X			X		X
Electrocardiographs	X		*X		X				X	X
Laboratory stirrers	X			X	X	X			X	
Machine tools		X	X		X	X	X		X	
Movie projectors	X		X	X		X		X		X
Office machines	X		X	X		X		X		
Packaging machines		X	X		X				X	
Photo printers		X	X		X		X	X		
Photo-copy machines	X	X		X	X			X		X
Portable tools	X	X		X		X		X		
Power rheostats		X		X		X	X		X	
Pumps			X		X	X			X	
Sound recorders	X		*X		X			X		X
Timing instruments	X	X	*X		X				X	X
Tower clocks	X	X	*X						X	X
Winding machines				X		X	X	X		

*Synchronous motor usually required.

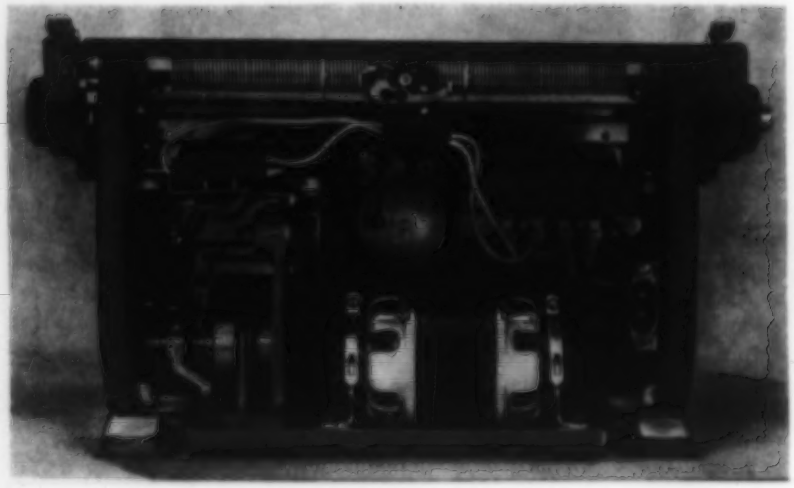


Fig. 5 — Typewriter (rear cover removed) showing alternating-current induction motor drive. Photo, courtesy Royal Typewriter Co.

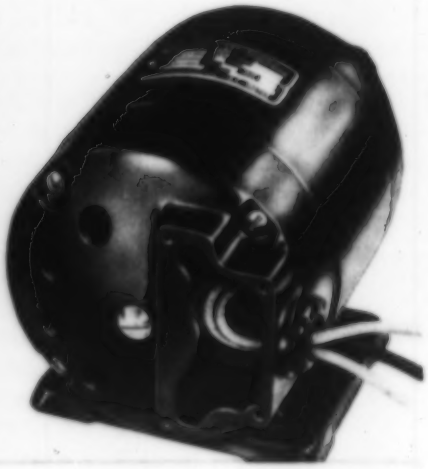


Fig. 6 — Ball-bearing fractional-horsepower motor with terminal box (cover removed) and standard base plate

starting and pull-up torque of the motor in relation to the driven load. Generally, the optimum running characteristics are sacrificed to some degree on motors designed for fast reversing service.

Multispeed motors are usually wound in capacitor, synchronous-capacitor, and polyphase types. The switching becomes quite complicated if reversible. These ac multispeed fractional-horsepower motors are usually made to order. Output (rating) is normally less than for single-speed motors of same frame size.

Starting and running torques, in general, are highest in a given frame with capacitor-start and series-wound motors for use on single-phase current, or with polyphase motors. Although sometimes overlooked, fractional-horsepower polyphase motors are available in ratings as low as 1/50-hp and less.

In applying fractional-horsepower motors, the maximum starting, accelerating and running torque must be carefully checked. If not tested under the most adverse load condition, the motor could fail to start, for example, under a peak cam load. Or, frequent unexpected overloads during running will cause the motor to overheat and eventually cause failure. Thermal overload protection or fusing is desirable on many applications to protect the motor against abnormal overloads or where accidental locking is probable.

Duty-cycle ratings should be determined in terms of time on and time off. On the basis of this information the motor can, if necessary, be wound for greater horsepower than is normal for the standard frame size without exceeding the maximum temperature rise rating for the insulation.

The duty cycle (continuous or intermittent) and the temperature rise (40, 50 or 55 deg C) are stamped on the nameplate of most motors. However, the temperature rise stamped on a motor nameplate is not necessarily the actual rise of that particular motor at rated horsepower since it may be lower in some cases. The temperature rise merely states in accepted standard terms the temperature class in which the motor falls. Most fractional horsepower motors are wound with Class A insulation where the maximum allowable total temperature is 105 C (ambient plus rise).

Operating motors at higher temperatures shortens their normal life. As a general rule, each 10-deg C increase in total temperature over the maximum permissible for the insulation class approximately halves the motor life. Continuous overloading also shortens motor life since the temperature rise increases approximately with the square of the load.

Where higher than 40 C ambient air is antici-

Fig. 7 — Sleeve-bearing fractional-horsepower motor with rubber-ring type resilient mounting

pated, many motor manufacturers are equipped to make accurate temperature versus time readings on a given application and can often suggest possible solutions. A general-purpose motor is a continuous 40-deg C rise open type, usable without restrictions with respect to kind of application.

Load Characteristics: A most basic point in the selection study is the matching of the motor to the load. Different applications impress certain load conditions on the motor and, therefore, influence the motor best suited as well as the horsepower required at the ideal speed. The actual load to be rotated can be divided into starting load, accelerating load, and normal running load. Besides these loads, fluctuating and/or overloads must sometimes be checked by experimental tests as well as in actual field tests. Frequently, in fact, a small-quantity pilot run is advisable with a newly motorized machine before regular production in large quantity is begun.

Starting load can be readily measured by weights or with a pulley and spring scale to determine the torque needed to overcome the static friction load. Accelerating loads are more complicated but can be calculated from known formulas. Even so, because of the complex shape and variety of moving parts in many applications, load test of the motor (under all conditions) is often preferred.

Running load is sometimes estimated by experienced designers but more often determined by testing. This load is referred to as the full-load torque developed by the motor at its rated speed. Most general-purpose fractional-horsepower motors are rated for continuous duty with a sufficient safety factor to take care of momentary overloads. However, the importance of complete load and heat tests on the motor should not be overlooked. Tests should be made first on the preproduction model, and later on the initial pilot run.

Fluctuating loads are difficult to determine exactly. In most cases several test runs are needed. The motor finally selected should be able to handle safely the worst load condition. Where quantity production warrants the engineering time, special motor windings can be developed to take care of unusual loads.

Radial load capacity of a motor is often estimated with the motor shaft diameter serving as a "yardstick." This method works well only if the load is applied near the motor bearing and the speed is considered, too. Where the load overhangs unusually far or fluctuating cam type loads are to be applied, these factors should be accurately specified in the early design stage. The same recommendation applies to high end-thrust loads, especially when applied to subfractional (below 1/20 hp) sleeve-bearing motors.

Mechanical Details: Once selection of the motor type and its characteristics has been defined, the next details to consider are those of mounting, coupling devices, braking, bearings, lubrication, and possible accessories.

Mountings are varied and include rigid base

Fig. 8 — Oscillograph recorder driven by small reducer motor and a fractional-horsepower flange-mounted ball-bearing vertical motor. Photo, courtesy General Radio Co.

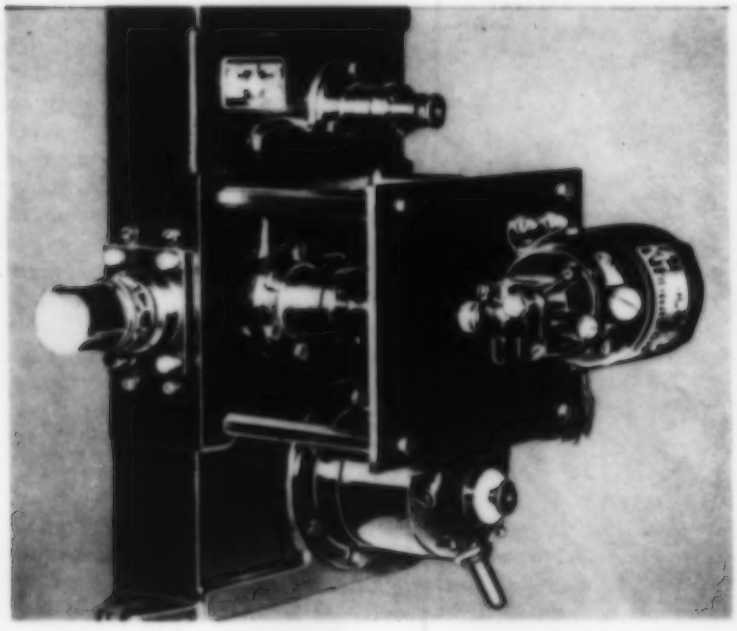


Fig. 9—Anesthesia pump powered by enclosed continuous-duty split-phase motor, face-mounted to pump housing for accurate alignment. Photo, courtesy Gomco Surgical Mfg. Co.

Table 3—Comparison of Mechanical Drives

Type	Compact	Flexible	Absorb Shock	Positive Drive
Coupling (rigid)	Yes	No	No	Yes
Coupling (flexible)	Yes	Yes	Yes	Yes
Coupling (fluid)	Yes	No	Yes	No
Clutch (slip)	Yes	Yes	Yes	No
Belt and pulley	No	Yes	Yes	No
Cog belt	No	Yes	Yes	Yes
Chain and sprocket	No	Yes	*Yes	Yes
Friction (cone or disk).	Yes	No	Yes	No
Reducer (worm gear) ..	Yes	No	No	Yes
Reducer (spur gear) ..	Yes	No	*Yes	Yes

*Limited shock absorption.

plates sometimes welded or held by screws to the motor center ring. If secured by screws, the base can be removed and the motor mounted by screws into the tapped holes in the machined bosses of the center ring, thus reducing motor height. In this connection, *Fig.* 6 can be compared with *Fig.* 4. Foot mounting are generally supplied in the NEMA 56 and 66 size motor frames.

Resilient mountings are commonly used to cushion and isolate motor vibration, *Fig.* 7. Usually a jumper wire is incorporated to ground the motor across the rubber insert.

Flange mounting, *Fig.* 8, is an effective space saver, and permits accurate alignment with direct gearing. Available also are NEMA Type C face-mounted shields, as well as motors with specially machined rabbets with tapped holes for accurate mounting, *Fig.* 9.

Stud bolts are ideal for hanging subfractional motors, such as from the scroll of a blower, or a fan bracket.

Mounting positions include every position from the standard horizontal to vertical, shaft up or down, plus wall and ceiling mounting. Many times the space available dictates the motor position. Except in the smaller horsepower ratings, specifying ball bearings is wise where the shaft is vertical because of end thrust. For rather light end thrust, such as exerted by small fans, sleeve bearings with thrust washers are successful. Ball thrust arrangements are also used.

Coupling devices are almost innumerable. In general, one of the following arrangements is used to link the motor to the driven load: direct shaft coupling (rigid or flexible), pulley and belt (round, V, or cog type), gear train (parallel or worm), and various clutches (including single or multiple-revolution types). The general advantages of several couplings or drives are shown in *Table* 3.

Gear-reducer motors save space and cost where low speeds are needed. The desired output shaft speed and torque (either in pound-inches or ounce-inches) are the terms to use in specifying the load. Usually gear-reducer motors are directly connected or coupled to the load. However, cams, clutches, chain and sprockets, and Geneva mechanisms sometimes are used to transmit the torque to the driven load. For longest gear life, care should be exercised so that the peak point in a varying load cycle does not recur on the same gear tooth. On loads which tend to lock, a suitable slip-clutch or shear pin is installed between the reducer drive shaft and driven shaft to protect gear teeth.

Ventilated or totally enclosed motors should be considered. Open, ventilated (fan-cooled) motors are usually built in either a drip-proof or semipro-

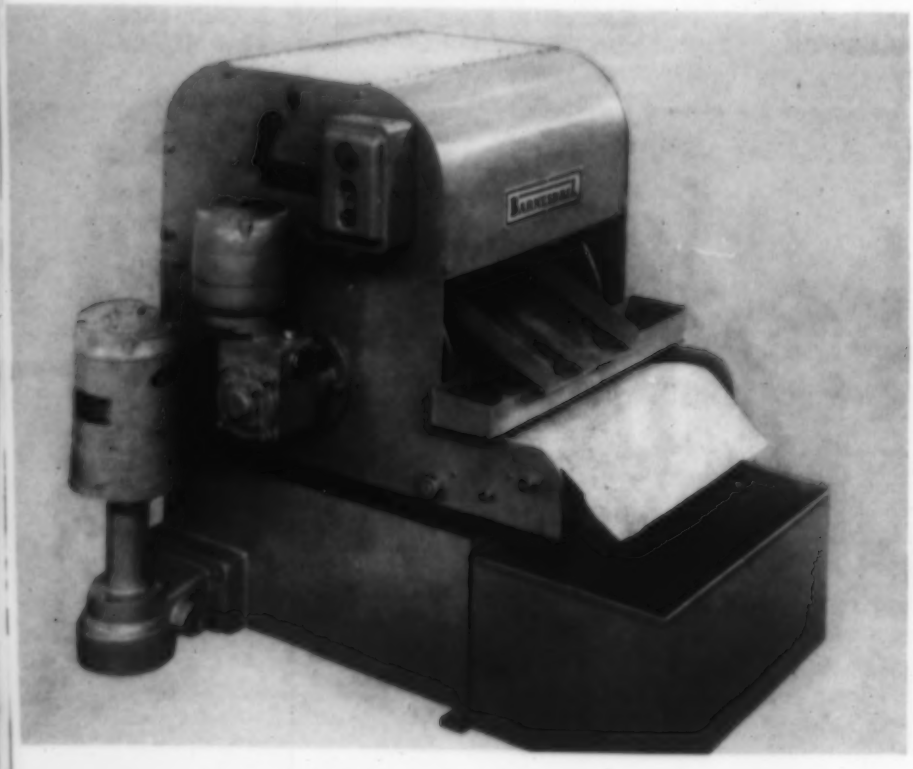


Fig. 10—Combination magnetic and filter coolant separator. Fractional-horsepower worm-gear reducer motor and ball-bearing vertical pump motor are both flange-mounted for direct connection to loads. Photo, courtesy Barnes Drill Co.

tected frame construction. In NEMA frame sizes of 56 and above, splash-proof ventilated motors are available from several motor manufacturers. Many fractional-horsepower enclosed motors are not fan cooled because they are designed for limited frame size, but in such constructions the design provides for transfer of heat by convection. For lowest maintenance, a totally enclosed motor is preferred for operation in dusty, humid, acid, or alkaline atmosphere. To protect the motor more fully under such atmospheric conditions, special insulation and protective coating or plating of frame parts is sometimes necessary.

Braking can be planned for in several ways. Magnetic brakes built into the motor are offered by some motor manufacturers, generally in ⅛-hp and higher. Brakes add to the motor cost, but are common on hoists and applications requiring quick stops and/or reversals under high inertia or overrunning loads.

Dynamic braking by shunting the capacitor is practical on some small permanent-split capacitor motors designed for this purpose with balanced windings. However, more effective braking can be achieved by dc braking—that is, impressing direct current on the winding. Polyphase motors can be braked also by impressing direct current across the winding. Today, it is economically feasible to obtain direct current by rectifying alternating current with dependable dry-disk rectifiers. These possibilities should be explored carefully; some motors cannot remain braked for indefinite periods, nor will they hold or lock all kinds of loads. Current required to brake a particular load may be too high for continuous motor operation if braking cycles occur frequently. Careful tests must be run with maximum temperature rise recorded under actual field operation before the motor is approved for braking service.

Quiet operation, to an extreme degree, can sometimes be costly in overall motor performance and increase the motor cost. Sleeve bearings are normally the quietest operating. But friction losses due to extremely close fitting sleeve bearings with very limited end-play, or close tolerance and highly preloaded ball bearings, must first be carefully analyzed against actual operating requirements.

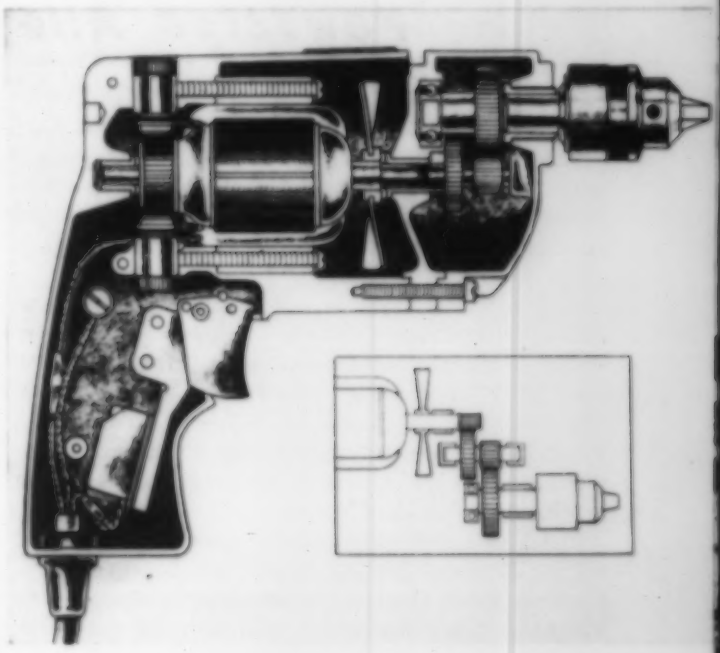
Many times, dynamic balancing and/or resiliently mounting the motor, or changing the shape or thickness of steel in the equipment case would be the better solution. Either the motor mounting support or the case can act as a sounding board, amplifying the sound. Sound level is important in many applications and can result from mechanical or magnetic vibration. Magnetic vibration can sometimes be reduced by changing the winding. Balance and movement of other driven members may have to be studied and accommodated in the overall design for best results.

Lubricant for ball bearings (or gears in the case of a speed-reducer motor) is determined by the operating temperature range and the atmospheric conditions. No gear lubricant is considered perfect over extremely wide temperature ranges, such as −50 deg C to 105 deg C. Hence, the selected lubricant is usually a compromise. This is another reason why the ambient (operating) temperature range should be accurately anticipated. Also high humidity or other abnormal atmospheric conditions are important factors in lubricant selection.

Good storage life on shielded or sealed ball bear-

Fig. 11—Above—Portable tools showing use of definite-purpose motor parts. Photo, courtesy Skil Corp.

Fig. 12—Below—Cut-away view of ¼-inch drill powered by high-speed series-wound motor parts driving through helical gearing. Photo, courtesy Porter-Cable Machine Co.



ings is also important. As a general rule, grease in ball bearing motors should be replaced if stored more than 18 months, even under constant, normal room temperatures. Sleeve-bearing or oil-lubricated ball-bearing motors should be relubricated as recommended by the manufacturer. The same recommendation applies to gear lubrication.

Optional motor accessories include leads of specified length or special leads to withstand high temperature, excessive humidity or oil, etc. Rubber cords with or without plugs are also frequently used. On-off toggle switches are also available. Conduit or terminal boxes are not usually considered standard on the smaller fractional-horsepower motors, but are commonly available.

Another feature often desirable is an overload protector. Responsive to excessive current, an overload protector is a thermal-sensitive device consisting of a bimetallic element placed close to the winding of a fractional-horsepower motor (usually on a split-phase type). There are two types: automatic reset and manual reset. The manual type is preferred when automatic restarting would not be safe. In either type the motor winding is protected and the protector continues to cycle until the cause of high current or heat is corrected.

Definite-Purpose Motors: Useful possibilities in special situations are offered by definite-purpose motors. They are those designed, listed and offered in standard ratings with standard operating characteristics or mechanical construction for use under specific service conditions or for use on a particular application. Such fractional-horsepower motors are available for oil burners, washing machines, coolant pumps, etc. A typical direct-connected coolant pump motor is shown in *Fig.* 10.

Series-wound motor parts, widely used in portable tools, where speed stability is not critical, also fall in the definite-purpose class, *Fig.* 11. Their inherent high speed, with high efficiency, results in maximum horsepower for given weight and size. Relatively high electric power can be absorbed because of the very efficient cooling system and the relatively intermittent duty. Brush life is good if brush material is carefully selected and ample cross-section provided for the full-load current rating. The cutaway view, *Fig.* 12, of a popular ¼-inch drill illustrates the gearing and housing features of a ball-bearing design. For accurate alignment the pinion is cut integral with the armature shaft.

Alternating-current induction motor parts consist of wound stator and rotor without shaft. These are favored for machine tool use and are normally wound for specific operating characteristics. Sometimes a "¾" ac motor (a motor supplied without one end shield) is the answer to a compact design where the motor is an integral part of the machine.

Final Considerations: Two additional factors should be kept in mind as motor types are studied for an application:

Initial cost vs maintenance is an important question. For example, a high-speed series (universal) motor costs less initially but may require more frequent servicing than an ac induction motor because of brush and commutator wear. Fractional-horsepower polyphase and permanent-split capacitor motors normally require less maintenance than a split-phase type.

In general, thought should be given to so locating the motor that it can be easily inspected and serviced. Brush caps and oilers on sleeve bearings should be accessible. In some applications, however, providing for removal of the entire motor may be more practical.

Powdered Alloy Steel Gears

Powder metallurgy techniques have been successfully applied to the production of mechanical parts requiring the properties of solid alloy steel. Three companies have jointly developed high-strength alloy steel gears made by the powder-metal process.

A prealloyed type of steel powder, 4650, was developed by Vanadium-Alloys Steel Co. Made by water disintegration of molten metal, the powder has been fabricated into gears with tensile strengths said to exceed 100,000 psi. According to Keystone Carbon Co., fabricators of the gears, resistance to wear of these gears is greater than previously used solid gears.

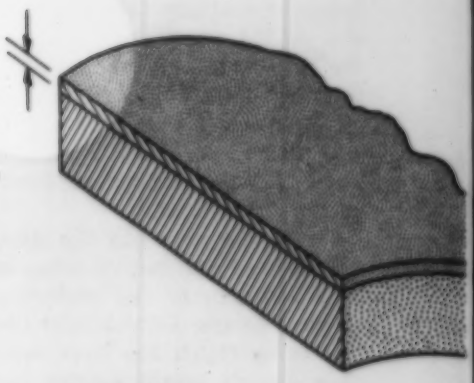
Field tests and accelerated life tests were carried out by Hydreco Div. of New York Air Brake Co. Hydreco made the final application of the gear to hydraulic pump equipment. Considerable cost savings and superior characteristics for the powdered steel gears are reported.

Powdered alloy steel gears in 1½-inch pitch diameter with lengths ranging from ¼ to 1½ inches are being produced. Uniformity from one gear to another, and surface finish on the teeth, is said to be acceptable both from a production and service standpoint.

Parts made from the prealloyed steel powder respond to heat treating in the same manner as parts made from bar stock having the same chemical analysis. This characteristic makes it possible to produce high-tensile strength parts over a range of density. Parts molded from the new powder have been found to have good green strength, permitting automatic handling prior to sintering. The molded parts do not decrease in size beyond controllable limits during the sintering operation.

Design specifications for

Chromium Plating Thickness



By J. B. Mohler
Consultant
New Castle, Pa.

CHROMIUM plating is widely used in hundreds of applications because of a unique combination of desirable properties. Bright chromium for decorative purposes is popular because the finish remains unchanged after years of service. The combination of brightness, corrosion resistance and wear resistance is not found in any other commonly used metal. Even though chromium plating is more expensive than other plating processes, the resulting deposit is more economical because of the long life of a thin deposit.

In addition to satisfying demands for appearance and economy, chromium has excellent corrosion resistance to conditions other than atmospheric. Chromium is quite resistant to wear because of its extreme hardness. Also chromium has a low coefficient of friction while in contact with other metals, so that it resists sticking, pickup and galling.

Since many applications for this metal are found in both decorative and engineering fields, it is common to use the terms decorative or bright chromium and industrial or hard chromium. Actually these metals are one and the same. Bright chromium is also hard and both types can be plated from the same bath under the same conditions. It is possible to vary the properties of the deposit by changing the bath conditions, but this is not ordinarily done.

Decorative Deposits: Chromium like all other materials does have some shortcomings. A thin deposit will not cover the base metal adequately for protection against corrosion, since the deposit is interlaced with microscopic cracks. Where chromium is used for protection against atmospheric corrosion, it is generally deposited over copper or nickel. These metals will adequately cover the base metal and are sufficiently corrosion resistant for long life. However, they will stain and dis-

Table 1—Minimum Thickness of Electrodeposited Metallic Coatings

Base Metal	ASTM Type*	Copper (min, in.)	Nickel (min, in.)	Copper plus Nickel, Total (min, in.)	Chromium (min, in.)	ASTM Spec. Reference
Steel	D.S.	.....	0.0010	0.0020	0.00001	A166-53T
	F.S.	.....	0.0006	0.0012	0.00001	A166-53T
	K.S.	.....	0.0004	0.00075	0.00001	A166-53T
	Q.S.	.....	0.0002	0.0004	0.00001	A166-53T
Copper	F.C.	.....	0.0005	.....	0.00001	B141-45
	K.C.	.....	0.0003	.....	0.00001	B141-45
	Q.C.	.....	0.0001	.....	0.00001	B141-45
Zinc	F.Z.	0.0003	0.0005	0.0012	0.00001	B142-53
	K.Z.	0.0002	0.0003	0.00075	0.00001	B142-53
	Q.Z.	0.0002	0.0003	0.0005	0.00001	B142-53

*Arbitrary designations.

color. A very thin deposit of chromium is used to produce both a corrosion-resistant and a stain-resistant combination. In *Table* 1 are shown ASTM types of coatings taken from tentative and standard ASTM specifications. This table shows that the minimum chromium thickness is 0.00001-inch in every case. For heavy-duty applications, such as automobile trim which is exposed to weather and unfavorable road conditions, type D.S. should be used. For indoor applications thinner undercoats may be used.

Chromium also has the disadvantage that it is not as easily buffed as other metals. Consequently, the finish of the underlying metal should be as good as the desired final finish. Common practice is to finish the base metal by buffing first, then deposit bright copper, bright nickel and finally chromium. If any buffing is done prior to final plating, the softer copper layer is usually buffed rather than the nickel.

Specifications for the combination of metals used, the desired thickness of each deposit, etc., are generally established by agreement between the manufacturer and the purchaser. For indoor applications it is not necessary to use an undercoating of copper, although nickel is generally used. It is really a matter of finishing economy. For plumbing or copper alloys exposed to wear and moisture a nickel undercoat is essential.

In the case of zinc alloys, copper is generally deposited prior to deposition of nickel to avoid bond difficulties. A minimum thickness of 0.0003-inch for copper is recommended to avoid eventual alloying of all the copper with the zinc.[1]

Engineering Applications: Chromium plating is used in various thicknesses for applications such as:

Aircraft and automotive parts	Metalworking machinery
Bearing races	Molds
Cams	Paper mill machinery
Chemical equipment	Printing plates
Cylinder liners	Pumps
Dies	Rubber machinery
Drying rolls	Scraper plates
Food products equipment	Sewing machine parts
Grinding machinery	Steam plates
Heat exchangers	Tanks
Leveller rolls	Textile machinery
Machine tool parts	Valves

Although some skill is required for heavy deposits it is a much-used skill in many plants and plating shops, and a recommended practice[2] is available.

Typical thicknesses of electrodeposited chromium for a number of applications are given in *Table* 2. These thicknesses are not definite recommendations, since the conditions for a specific application may dictate the use of some other thickness. Properties of the deposit and success in typical applications may be used as a guide. Unlike decorative chromium plating, functional chromium deposits are usually applied direct to the steel, since underlying deposits usually used for decorative plating are soft.

1. References are tabulated at end of article.

Fig. 1 — Difficulty encountered in chromium plating corners. Grinding and replating may be necessary

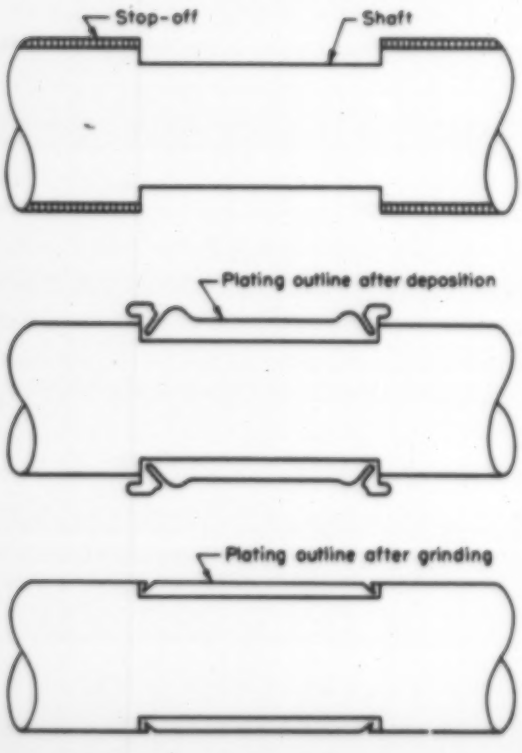
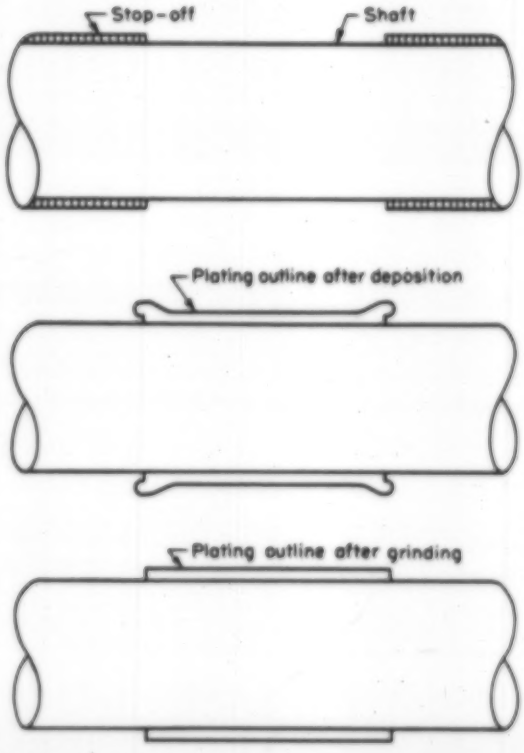


Fig. 2—Procedure for chromium plating on a straight shaft



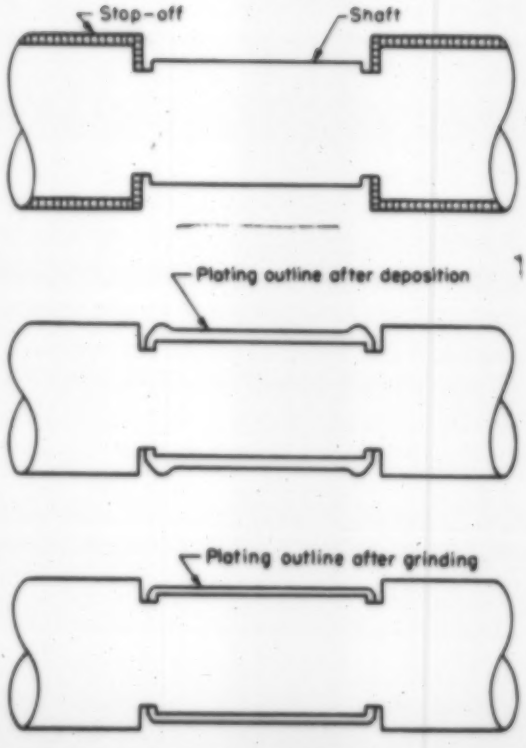
THIN AND HEAVY DEPOSITS: Thin deposits are generally used where surface properties are of primary importance. Deposit thicknesses in the range of 0.00001 to 0.0001-inch will impart low friction and antisticking properties. At the same time such thicknesses will faithfully reproduce the surface of the underlying metal. Thin deposits have the advantage of needing no further finishing steps after the plating process. Often a thin deposit is required where heavy loads might fracture a brittle, heavier deposit.

Heavy deposits are used where wear and corrosion are factors. Such deposits are in the range of 0.001 to 0.025-inch and are usually ground, lapped or honed to size after plating oversize. For such heavy deposits 0.001 to 0.010-inch may be allowed for grinding stock; this depends on the size and shape of the work along with the precision required.

The chrominum plating bath has the lowest throwing power (ability to fill in corners) of any of the plating baths. This poor throwing power results in excessive build-up of metal on edges and outside corners and extreme difficulty in suitably plating inside corners, *Fig.* 1. If this factor is not taken into account, plating time may be as much as five times that normally required. It may even be necessary to plate, grind and replate to get metal into the corner.

Plating steps and results similar to those demonstrated in *Fig.* 1 are depicted for a straight shaft in *Fig.* 2 and for a recessed shaft in *Fig.* 3.

Fig. 3—Procedure for chromium plating on a recessed shaft



There is a further advantage in specifying chromium surfaces. After they become worn they can be stripped and the part can be replated to the original size; or surfaces can be plated and finished oversize to compensate for wear on the mating part.

PLATING ON SHAFTS: Many shafts are chromium plated for long life and low friction. Where light loads and clean lubricant can be expected, thin deposits can be used. Conversely, where heavy loads or contact with dirt is likely to be encountered, heavier deposits will be required. Although the brinell hardness of chromium is in the range of 700 to 1000, the layer will not be strong if it is thin. A particle will crush the thin layer and become embedded in the soft base metal. This may be partially overcome by specifying a hard steel base of Rockwell C60 to C64 hardness although for shafts the lower hardness limit may be C55. Even with hard steel it will be necessary to use a heavy deposit to resist abrasive wear.

In general, thickness of chromium for a wear application will be a little heavier than the wear tolerance allowed, so that some chromium will be left for stripping when the part is salvaged by replating. Replating and salvage of parts is a factor of considerable economic importance.

Hard alloy steels are used in most applications, and these steels become embrittled because of evolution of hydrogen during plating. This embrittlement can result in a part cracking in service. This hydrogen may be removed by heating for 1 to 5 hours at 300 to 500 F after the part is plated. The specific temperature and time used depends on the application, the amount of cold working of the part

Table 2—Typical Thicknesses of Electrodeposited Chromium

Application	Thickness (in.)
Decorative over copper and nickel	0.00001 to 0.00002
Dies	
Drawing	0.002 to 0.003
Drawing, large	0.005 to 0.010
Drawing, deep	0.0002 to 0.001
Forming	0.001 to 0.002
Stamping, shearing and blanking	0.0002 to 0.001
Coining	0.0002 to 0.0005
Molding, plastics	0.0002 to 0.0005
Molding, clays	0.001 to 0.002
Pump shafts	0.0005 to 0.0015
Pump shafts, high pressure packing	0.002 to 0.003
Large shafts	0.004 to 0.005
Hydraulic equipment	
Run-in packing	0.0005 to 0.0015
Run-in cylinder	0.001 to 0.002
Machine parts	0.0005 to 0.002
Printing plates	0.0002 to 0.0005
Large rolls	0.010 to 0.015
Operating equipment	0.010 to 0.015

before plating, and the amount of exposure in the bath.[3]

PLATING ON RAMS AND PISTONS: A heavy chromium layer should be specified for heavy-duty sliding parts where low friction is desired and abrasive wear is encountered. In some such applications corrosion may also be a factor.

PLATING ON ROLLS: Heavy duty rolls used for producing a smooth or embossed surface on plastic, leather, rubber or fiber board should be plated with a heavy deposit of chromium. Rolls heavily plated offer advantages of good reproduction, freedom from scratching and absence of pick-up.

Smooth rolls may be ground, lapped and finally buffed to produce a mirror finish. For rough patterns a fairly heavy deposit may be applied without grinding to size after plating.

Where smooth rolls are used for drying of paper and corrosive chemicals, the thickness required depends on the corrosive action of the chemicals. Chromium is not anticorrosive, it is merely highly corrosion resistant to a number of chemical solutions.

PLATING MIXING EQUIPMENT: Chromium has been successfully used in mixing equipment designed to handle food products, plastics and other materials. This metal is nontoxic for food products and is resistant to wear and sticking for gum-like materials. Relatively thick deposits can be applied without sizing, since the size of the beaters is not critical.

REFERENCES

1. W. A. Wesley and W. H. Prine, *Practical Nickel Plating*, International Nickel Co., New York, Page 21.
2. *Recommended Practice for Chromium Plating on Steel for Engineering Use*, Standard B177-49, American Society for Testing Materials, Philadelphia, 1949.
3. *Specifications and Tests for Electrodeposited Metallic Coatings*, American Society for Testing Materials, Philadelphia, September, 1953.

Drafting Reference Board

WHERE to keep reference drawings without having them interfere with the work at hand is always a problem.

Naturally, if floor space is available, a table next to the board will serve the purpose. However, where floor space is at a premium, reference notes and drawings tend to encroach upon the draftsman's work space. Also, much time is consumed in getting up from the board to look at reference drawings.

One solution to this problem is a floor-mounted collapsible reference board designed to hold the drawings in place with permanent magnets. A system of arms and counterbalances allows the board to be turned and raised or lowered easily. In addition, it may be hidden out of sight under the drawing table when not in use. *Fig.* 1 is a line sketch of a reference board of this type.

Spring counterbalances at two points provide for holding the 3 by 5-foot metal reference surface at any vertical position. Vertical movement is facilitated by rollers which permit up and down movement and, because of their design, also permit rotation of both the board and the arm upon which it is mounted. Ball-bearing swivels act as thrust bearings at the ends of the rotatable columns to permit their rotation. *Fig.* 1 illustrates the various parts of the board assembly and shows the location of the counterbalance springs. Expanded metal or steel bonded to aluminum may be used as the reference surface to provide the necessary magnetic qualities and make a lighter assembly.—BY JOEL RUBEL, *Dallas, Texas*

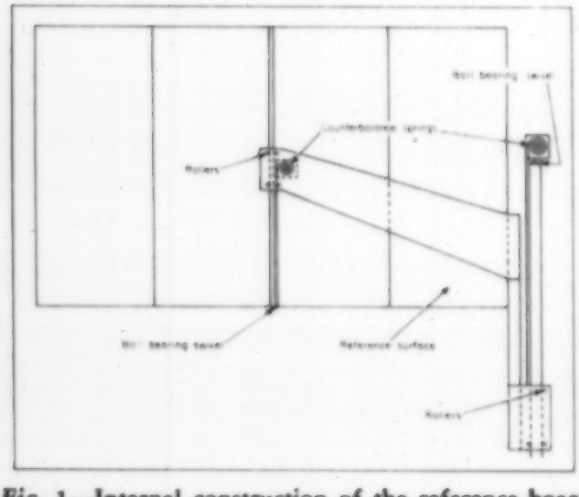


Fig. 1—Internal construction of the reference board showing location of spring counterbalances, rollers and swivels

"American industry is made up of an enormous number of small companies. Because these small enterprises account for such a large part of the total productivity, it is important that more consideration from the research viewpoint be given them instead of the large proportion of studies directed toward the relatively larger ones. Many small companies have research departments or programs that operate with greater efficiency and demonstrate their superiority to those of the larger corporations." — HAL F. FRUTH, *consultant and physicist, H. F. Fruth & Associates.*

Design with Tubing

How to design fluid-system components and tubular mechanical parts to take advantage of practical production techniques

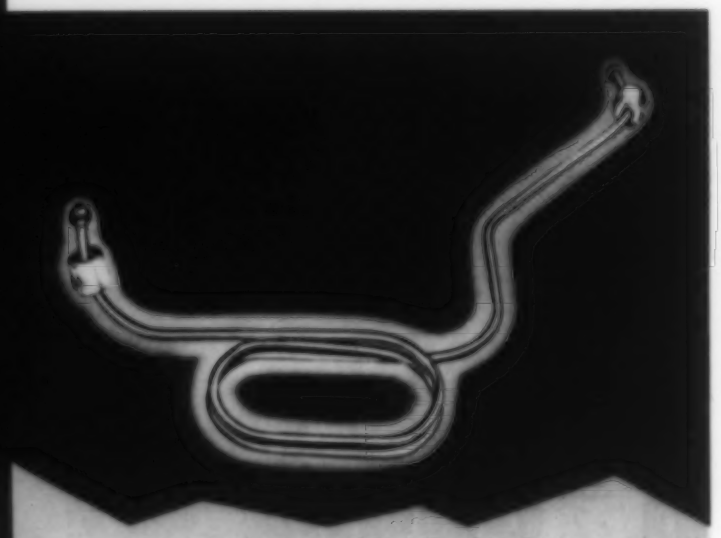
By W. O. Nussear Jr.
Superior Tube Co.
Norristown, Pa.

DESIGN of machine components from tubing depends strongly on production methods. For fluid lines in hydraulic systems, or fabricated structures, production methods may be relatively simple. Free bends made by hand are common, although higher production or critical nature of the component may call for bending on dies or fixtures.

A variety of unusual components, however, can also be produced from tubing—and parts produced from tubular sections deserve more than passing attention. Tubing can be bent to form structural parts or fluid systems, as previously indicated, but it can also be flanged, reduced, tapered and otherwise formed by reasonably inexpensive production methods. The main requirement for these machine parts is that they be essentially circular and symmetrical about a central axis, *Fig.* 1.

Production methods for tubing generally fall into two major areas: bending and forming. In general, bending involves a change in direction of the tube's axis, *Fig.* 2. Forming implies a change in

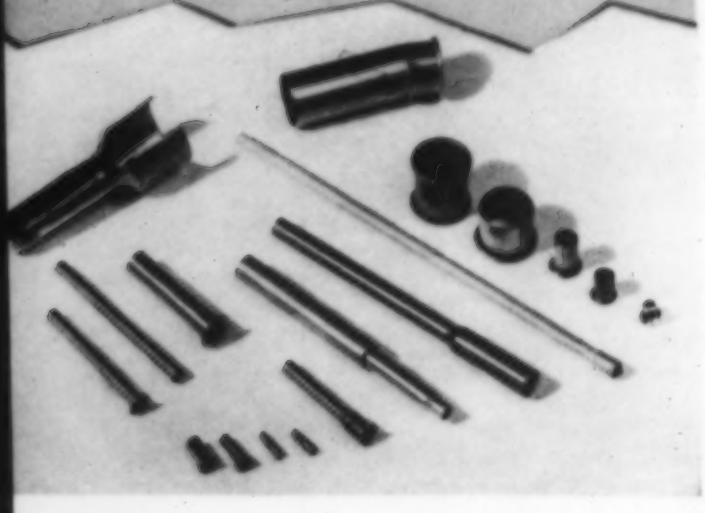
Fig. 1—Formed tubular parts must be essentially circular. Upsetting and rolled ends shown are produced by press forming, with intermediate flaring and flanging steps for the rolled-end components



Photo, courtesy Caterpillar Tractor Co.

Fig. 2—Above—Tubing bends can be in several planes. Component is a diesel fuel-injection line with ends upset for pressure-tight connections

Fig. 3 — Below — Beading, flaring, flanging, upsetting, reducing, swaging and bending are all used to produce stainless-steel and nickel electronics parts. Longest tube is 0.005-inch wall stainless steel with a hexed end



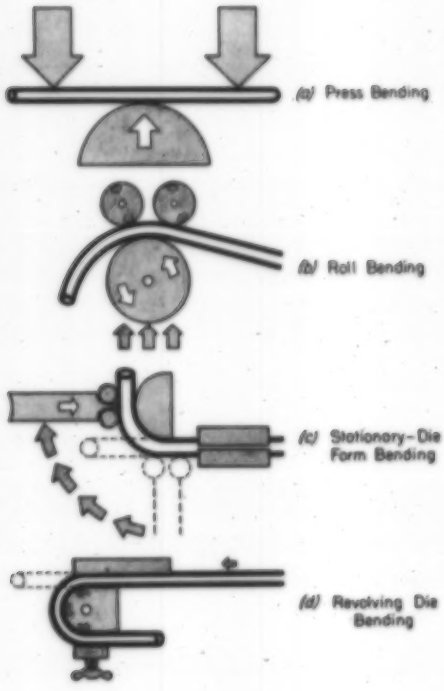


Fig. 4 — Production methods for bending tubing

the cross section of the tube, either in area or shape, *Fig.* 3.

Tube Bending: While close bends are often necessary because of space limitations or for the sake of appearance, such bends often stretch the metal 40 per cent or more. While the resultant thinning out of the wall may be compensated for by increased tensile strength, such stretching may give rise to tensile breaks, or wall thickness at the point of maximum stretch may be reduced to almost half the original.

If the tube is part of a hydraulic system, care must be taken to eliminate or minimize as many causes of turbulence as possible. This requirement calls not only for clean, smooth tubing but also bend radii of 2½ to 3 times the *inside diameter* of the tube. High-pressure stainless-steel hydraulic tubing is held to the minimum bend radii shown in *Table* 1 for this reason.

There are five basic methods of bending ferrous and nonferrous small-diameter tubing, *Fig.* 4.

1. Press bending
2. Roll bending
3. Stationary-die form bending
4. Revolving-die bending
5. Bending with a filler

PRESS BENDING: Regardless of the equipment used, press bending is any bending operation accomplished by a straight-line action of a bending force, *Fig.* 4*a*. This method is particularly adapted to the forming of heavy wall tubing (wall thickness equal to 20 per cent or more of the OD), and requires a minimum radius of bend of approximately 6 times the diameter of the tube if wrinkles and flat spots are to be avoided. Included angle of bend must be 120 degrees or less. Filler materials must be used in the tube if small bend radii are required. In addition, straight lengths between bends of at least 2 diameters are necessary. Fuel-injection tubes and other relatively heavy-wall small-diameter tubes are sometimes bent by this method.

ROLL BENDING: The same principle is used in roll bending of tubing as in roll bending of sheets into cylinders. Three grooved rolls, power driven, are employed, *Fig.* 4*b*. Radius of the grooves must be reasonably close to that of the tubing if

ovality is to be avoided. The method is particularly suited for bending complete circles, *Fig.* 5, or helical coils, *Fig.* 6. The practical minimum radius of bend is approximately 6 times the diameter of the tube, but smaller radii have been accomplished by the use of filler materials. Bends in more than one plane cannot be made close together.

STATIONARY-DIE FORM BENDING: For small tubing up to ⅝-inch OD, this method is one of the most common. The tube is wrapped or wiped around a grooved bending die to form the desired shape, *Fig.* 4*c*. Both circular and noncircular bends are possible, and several curves in two or more planes can be produced by means of special dies. Where the bend is 45 degrees or more, the minimum radius must be at least 2½ times the diameter of the tube. From the mechanics of the method, bends are obviously limited to about 180 degrees. Experience indicates that when bending to the minimum possible radius, flattening of as much as 5 per cent of the diameter may occur. The method is very versatile inasmuch as it may be applied where only a few parts are to be bent or may be used on a production job where thousands of similar pieces must be made. This same principle is used whether the equipment is a simple hand bender or a large machine weighing many tons.

REVOLVING-DIE BENDING: Instead of wrapping the tube around the die, the same purpose can be accomplished by rotating the die and keeping the bending shoe stationary, *Fig.* 4*d*. This is revolving-die bending. The method is particularly advantageous for the bending of thin-wall tubing to small radii, since the tubing can be entirely confined externally and internally at the point of bend. The minimum possible radius varies somewhat with wall thickness, but radii as small as 1½ times the diameter of the tubing have been successfully made. Maximum angle of bend with standard dies is 180 degrees, so that the tube can be removed without springing it open again. With special dies, helical coils can be bent. The method is usually limited to bending circular curves in one plane. Clamping length for thin-wall tubing should be at least 3 times the diameter of the tube. Square and rectangular tubing is often bent by this method, but speed is limited.

BENDING WITH A FILLER: Before any of the machine methods of bending were developed, tubing was bent by filling it with some material to prevent the walls from collapsing and wrinkling. These methods are still the best for bending extremely light-wall tubing (wall less than 3 per cent of OD), particularly to sharp radii. Some of the filler materials which have been used include dry sand of varying grit size, tar, beeswax, lead, rosin and Wood's metal. The latter is probably the most satisfactory because it has a very low melting point of 158 F and can be readily removed in boiling water. This alloy of bismuth, tin, lead and cadmium is available under various trade names. It has the advantage of expanding slightly upon solidification, thus producing a tight fit inside the tube. Free bends are frequently per-

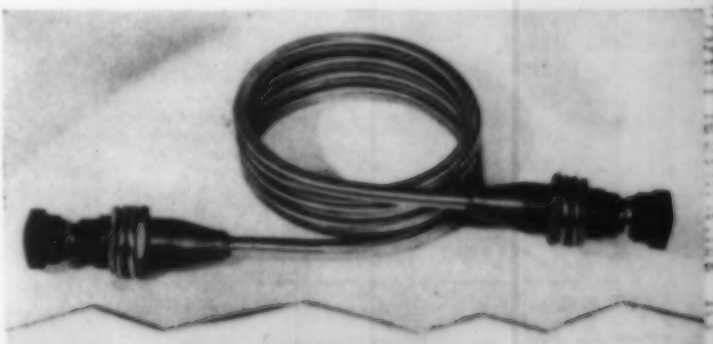


Fig. 5 — Above — Roll-bent nickel-alloy immersion heater

Fig. 6 — Below—Helical-coil stainless-steel heat-exchanger tube produced by roll bending

Photo, courtesy Graham Mfg. Co.

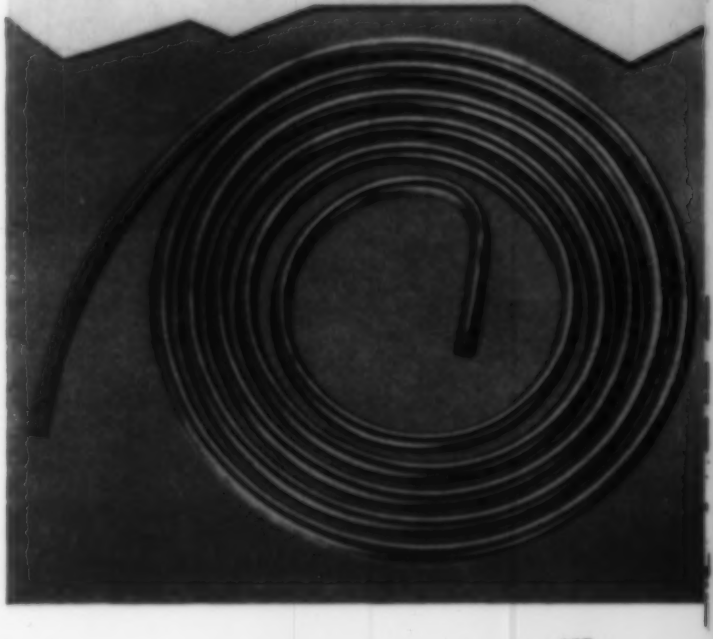


Table 1—Recommended Minimum Bend Radii for High-Pressure Tubing*

Tube Diam (in.)	Min Bend Radius (in.)	Tube Diam (in.)	Min Bend Radius (in.)	Tube Diam (in.)	Min Bend Radius (in.)
1/8	1/2	5/8	1 1/2	1 5/8	5
1/4	1/2	3/4	1 3/4	1 1/2	5
3/8	11/16	7/8	2	1 5/8	6
5/16	11/16	1	3	1 3/4	7
1/2	1 1/4	1 1/8	3 1/2	2	8
5/8	1 1/4	1 1/4	3 3/4		

*For stainless-steel aircraft hydraulic tubing.

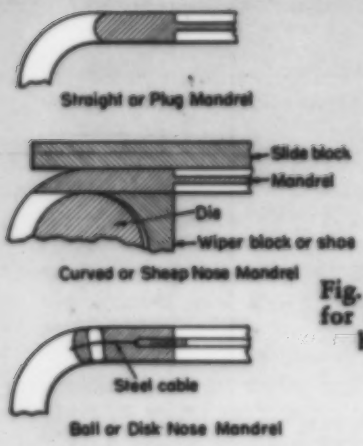
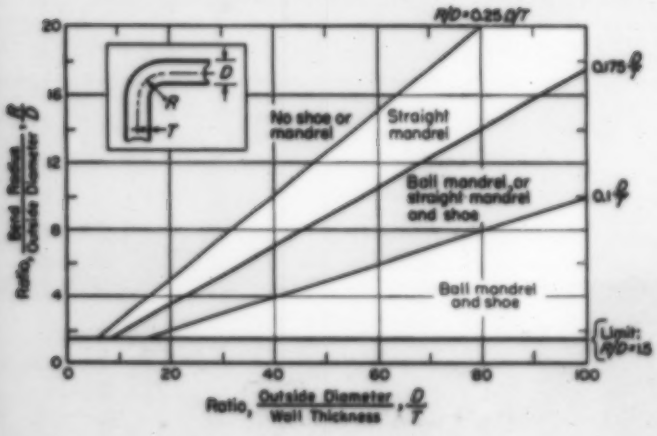


Fig. 7—Mandrels used for better support in bending tubing

Fig. 8 — Below — Mandrels needed for bending austenitic chromium-nickel stainless-steel tubing. Some indication of relative difficulty can be gained


R/D=0.25 Q/T
0.175 Q
0.1 Q
No shoe or mandrel
Straight mandrel
Ball mandrel or straight mandrel and shoe
Ball mandrel and shoe
Limit: R/D=1.5
Ratio, Bend Radius / Outside Diameter = R/D
Ratio, Outside Diameter / Wall Thickness = D/T

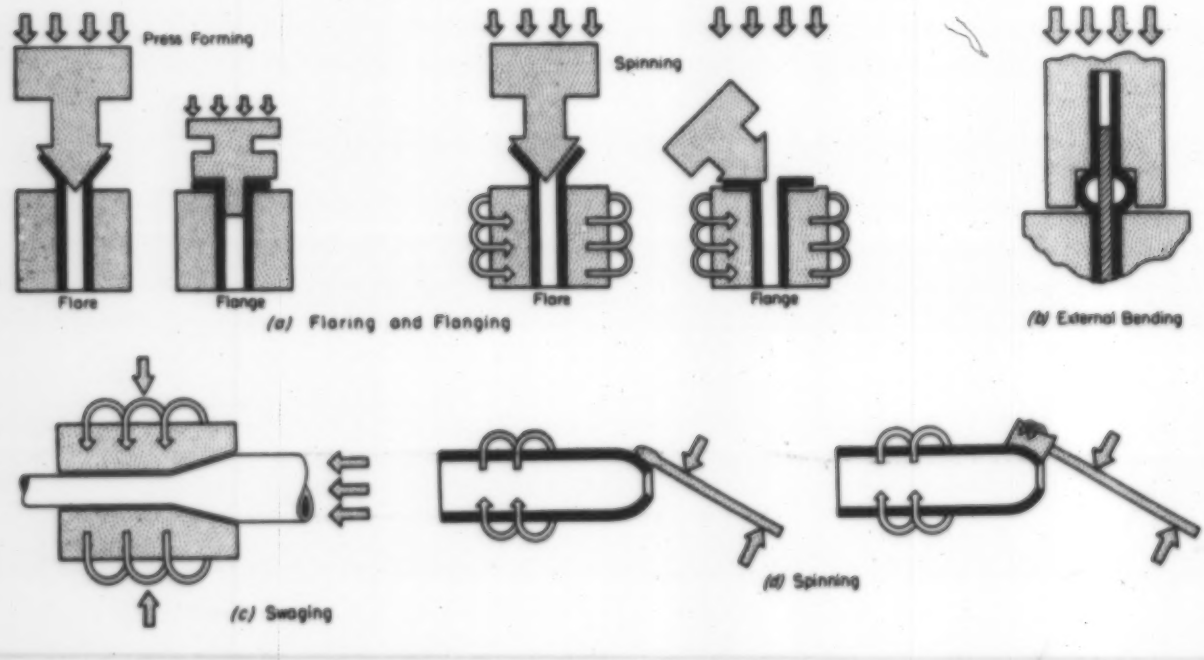
formed with a Wood's metal filler, but all the bending method described can be applied to a filled tube.

DESIGN FOR BENDING: Relatively heavy-wall tubes can often be satisfactorily bent without internal support, but as ratio of wall thickness to outside diameter decreases, the inside of the tubing must be supported to prevent collapsing. The thinner the wall with relation to OD, the more elaborate the precautions become. For very thin-wall tubing not only must an internal mandrel be supplied, but also a wiper block or shoe, and follower block as well. Under these conditions, the tube is fully supported around its entire circumference both internally and externally. Minimum bend radii imposed by mechanical methods of bending are shown in *Table* 2.

For long, sweeping bends a straight or plug mandrel is quite satisfactory, but as wall thickness or radius of bend is reduced, even better support must be provided by employing a "sheep nose" mandrel and shoe, or wiper block, *Fig.* 7. The ball or disk-nose mandrel is used for the thinnest tubing in order to provide support to the outer wall beyond the point of bend.

Outside-diameter to wall thickness ratios in relation to minimum bend radius required in the selection of mandrel type for bending tubing are indicated in *Fig.* 8. Some indication of relative difficulty and cost can be gained. These values are for austenitic chromium-nickel stainless steels in particular, but apply to most other materials, the limitations being ductility and work-hardening rate. In general, the principles discussed in this article apply to all materials with good ductility, but those that work harden more rapidly than stainless steel require more power and quite likely lubricants having greater film strength.

Fig. 9—Production methods for forming tubing



Tube Forming: While bending is perhaps the most common tube-fabricating operation, tubing can be flanged, flared, expanded, beaded, tapered and reduced to form parts or end configurations of many types, *Fig.* 9. Most of these operations are performed cold, although intermediate anneals may be necessary to improve ductility. If the tubing material has sufficient ductility to be cold drawn, forming operations can generally be performed. Increased power, more intermediate anneals and lubricants with higher film strength are required for higher work-hardening rate alloys such as titanium, straight chromium (ferritic) stainless steels, etc. Soft copper, copper alloys, aluminum and mild steels are the most easily formed materials, with nickel and nickel alloys, alloy steels, stainless steels, and titanium and other reactive metals and alloys showing increasing resistance to the flow of metal required by each forming operation.

In addition to temper of the metal, consideration should be given to the OD-wall thickness relationship (cross-sectional area) since there must be sufficient mass of metal at the point of working to withstand the expansion or contraction required and still allow smooth configuration without the formation of fissures, ruptures or wrinkling. Successful forming is thus a combination of metal

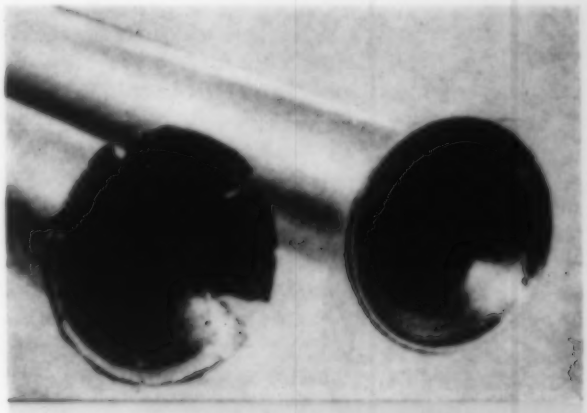


Fig. 10 — Above — Difference between a good flare and a poor one. Flaring subjects tubing to severe stretching, and must be carefully specified

Fig. 11—Below—Steps in producing a double flare, usually made on aluminum, copper and thin-wall carbon-steel tubing. Tubing illustrated is brazed double-wall steel

Photo, courtesy Imperial Brass Mfg. Co.

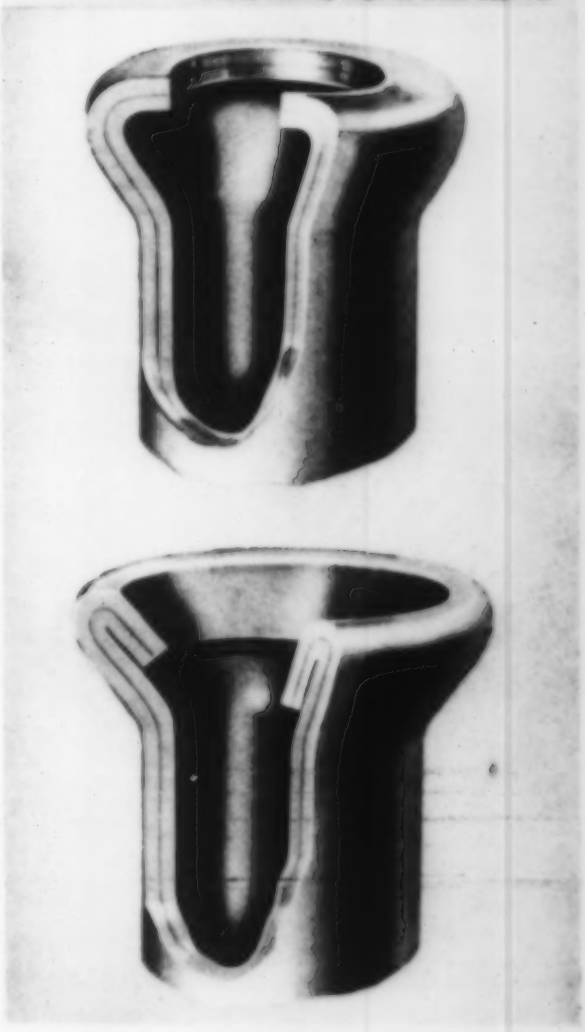


Table 2—Minimum Bend Radii for Various Production Methods

Bending Method	Tools	Min Radius (× tubing OD)
Press	Between centers	6
Press	Wing dies	3
Roll bending	Three groved rolls	6
Stationary die	No mandrel	2½
Stationary die	With mandrel	2
Revolving die	No mandrel	3*
Revolving die	With mandrel	1½*
Revolving die	With mandrel and shoe	1*

*Minimum radius is governed by wall thickness; minimum radius for very thin wall tubes (wall 3 per cent of OD or less) may be 2 × OD with mandrel and 1½ × OD with mandrel and shoe.

Table 3—Minimum Flare Increase for Tubing Used with AN Fittings*

Nominal OD (in.)	Expanded OD (in.)	Minimum Increase (%)	Nominal OD (in.)	Expanded OD (in.)	Minimum Increase (%)
0.188	0.290†	54.3†	0.750	0.937	24.9
0.250	0.359	43.6	1.000	1.187	18.7
0.312	0.421	34.9	1.250	1.500	20.0
0.375	0.484	29.1	1.500	1.721	14.7
0.500	0.656	31.2	1.750	2.106	20.3
0.625	0.781	25.0	2.000	2.356	17.8

*Minimum increase of OD specified in government specifications for pressure-tight connection with AN fittings. Materials covered are carbon and stainless steel, Monel, and aluminum. Flare is made by forcing tubing axially over pin having 74-degree included angle (37-degree flare) to produce a flare having a permanent expanded diameter.

†Expanded OD of 0.302-inch, 60.6 per cent minimum increase recommended for 0.188-inch nominal OD with Monel and aluminum.

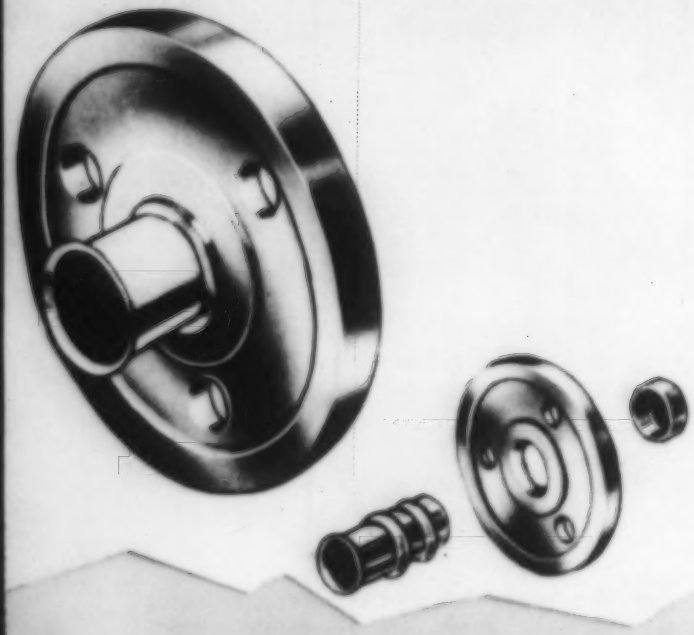
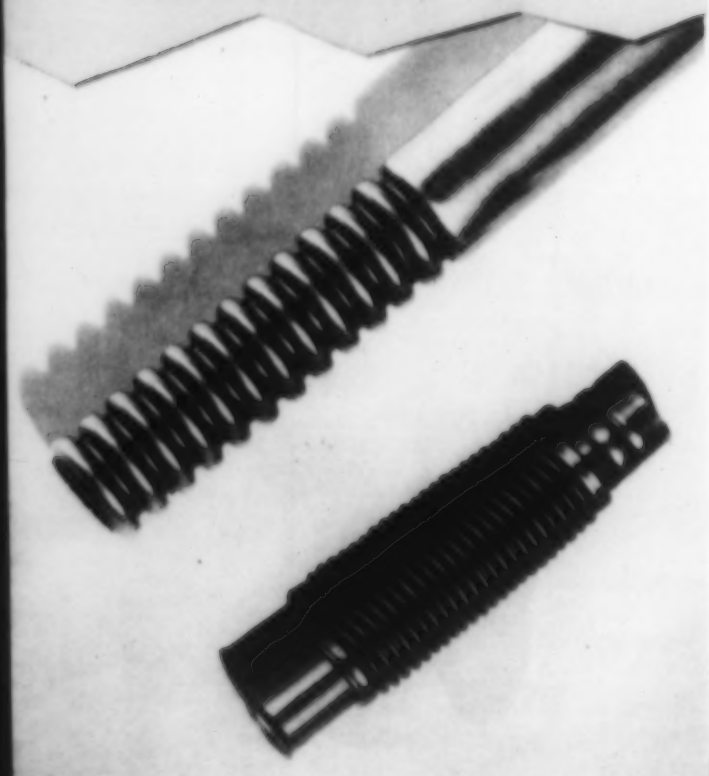


Fig. 12—Above—External beads rolled into thin-wall nickel tubing position a ceramic disk-cathode assembly for television and other cathode-ray structures

Fig. 13—Below—Reducing is first operation on seamless flexible hose, top, while shorter seamless stainless-steel bellows tubulation, bottom, is expanded



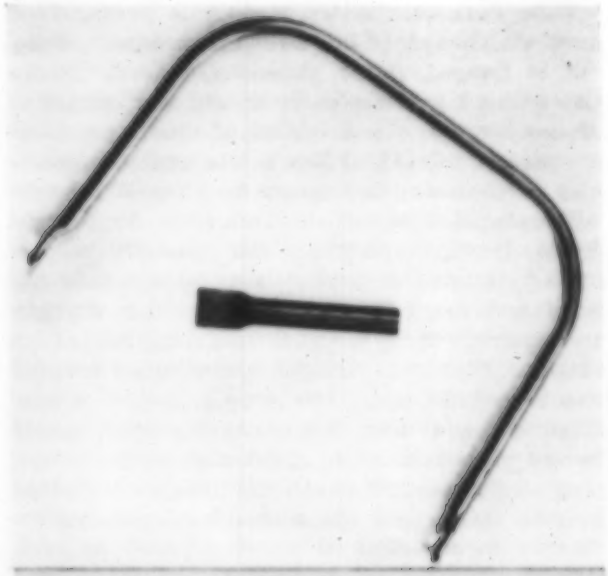


Fig. 14 — Bent, flattened and drilled coping-saw frame, and flattened bracket for an automotive application. Both parts are low-carbon steel

characteristics, temper, tooling, lubrication and size of tubing.

FLARING: Maximum permissible flare diameter is a function of outside diameter, wall thickness and temper of material. During flaring, *Fig.* 9*a*, the edge of the tubing is subjected to severe stretching, *Fig.* 10. The cut end must be perpendicular to the axis of the tube, and edges must be cleanly deburred but not chamfered to a feather edge. Flare diameters should be limited to 160 per cent of OD for annealed tubing and 150 per cent for slightly work-hardened tempers. Maximum flare diameters may be somewhat less for sizes over 1 inch OD.

Sometimes a minimum flare is also necessary. For example, *Table* 3 indicates expansion specified for pressure-tight connection with AN fittings. Figures are those specified in government specifications for carbon and stainless steel, Monel and aluminum. A double flare required of aluminum, and sometimes thin-wall carbon steel and soft copper, *Fig.* 11, proves to be a big advantage when joints are to be reconnected frequently.

Flaring may be accomplished either by axial pressure of a conical tool in a press or by a special flaring machine which uses an eccentrically rotating conical tool which spins the flare into a conical recess in a split die. Where sufficient production of flared-end tubing is required, the spinning method is recommended, since larger-diameter flares and fewer cracks result.

FLANGING: Called Van Stoning on larger tubes, flanging is accomplished in two operations—by either press-forming or spinning a flare and then finishing the operation in another set of dies by

either method, *Fig.* 9*a*. Again, the spinning method is preferred since less galling and seizing is likely to occur. Flanging may be carried one step further and the flange turned under to form a roll.

BEADING: Both internal and external beading are often accomplished by taking advantage of the natural tendency of a thin-wall tube to buckle under axial pressure, *Fig.* 9*b*. With this method, the tube is surrounded by a split die and provided with tight-fitting internal plugs. Cavity for the bead is cut into the external dies or between the internal plugs as required. Axial pressure or a sharp blow causes the tube to fill the cavity.

A more accurate method of beading is by spinning; a small roller is applied either internally or externally as required, which forces the metal into a conforming groove in a matching die or roll, *Fig.* 12.

EXPANDING OR REDUCING: It is much easier to stretch metals than to compress them. For this reason, short tubular parts of stepped design are sometimes more easily made by expanding to a larger diameter instead of reducing to a smaller one, *Fig.* 13. However, with proper lubrication and careful tool design, tubing may be swaged, spun or sunk to reduced diameters, or even to a point, *Figs.* 9*c* and *d*.

Heavy-wall tubes may be expanded with a punch and die, but special lubrication methods are required. Thinner tubing may be expanded by spinning, hydraulic pressure or the rubber-pad technique extensively developed in the aircraft industry. Segmented expansion arbors, either cam or screw-operated, are often used for slight expansion of larger tubes. Because of the stretching involved, thin-wall tubes should not be expanded in diameter more than about 35 per cent and, as in flaring, particular attention must be paid to the edge condition.

Thin-wall tubing (walls less than 7 per cent of the OD) in the annealed condition can be flattened wall to wall, but for heavier walls the flattened dimension should be limited to 3 times the wall thickness, *Fig.* 14. Flattening to less than 5 to 7 times the wall thickness is not advisable for half-hard or full-hard tubing unless the wall is extremely thin (less than 3 per cent of OD).

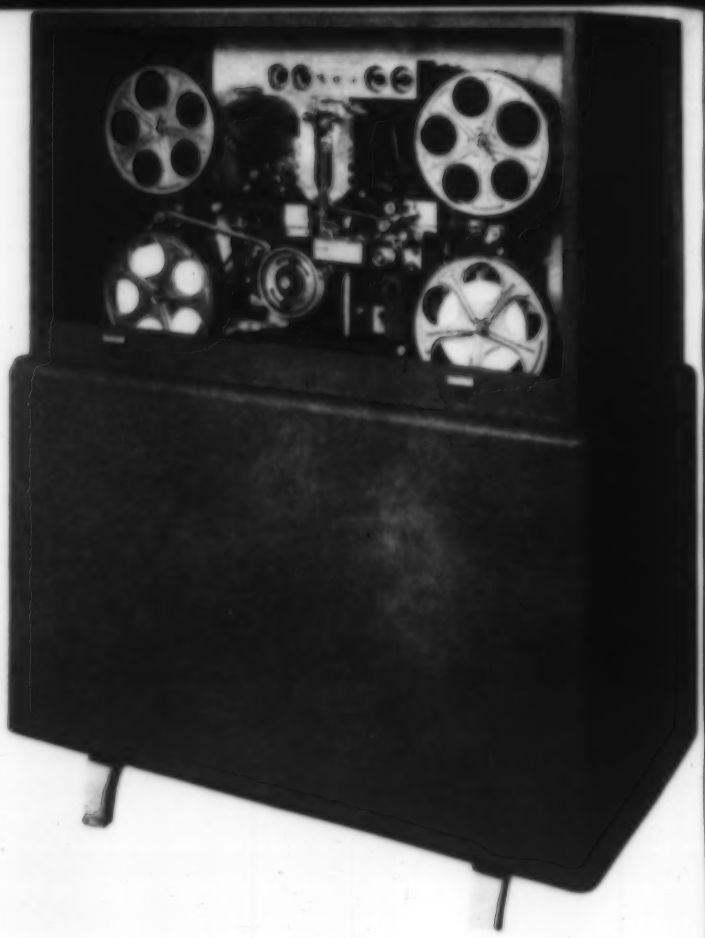
CONTEMPORARY DESIGN

Water Cooler Is Also Heater

IN RECOGNITION of what seems to have become a tradition, the coffee break, two recently introduced water coolers also heat water for use with instant coffee or tea bags. Both models, pressure and bottle types, are called the Oasis Hot 'N Cold Water Cooler by the maker, Ebco Mfg. Co. Bottle type has two pushbutton spigots on the front of the cabinet. Cold button is blue; hot button is red. Pressure model has an extra gooseneck spigot with a red handle for hot water in addition to the conventional cold-water spout.

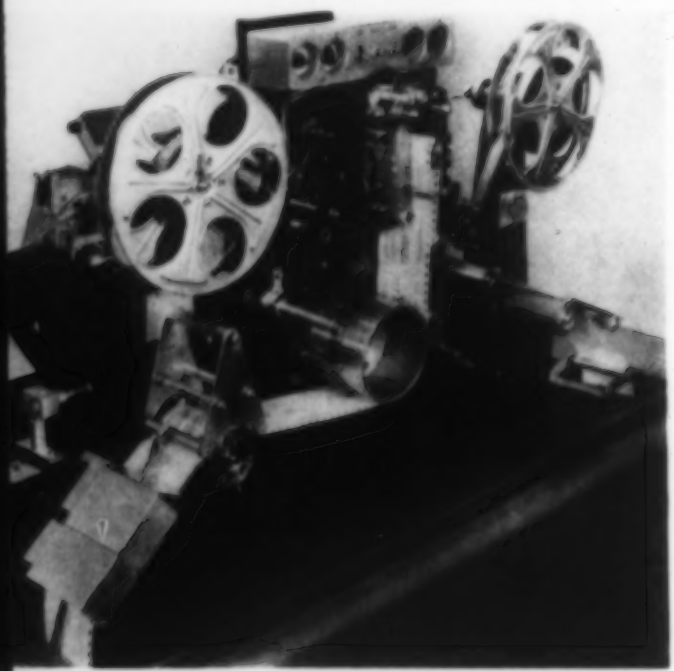
Hot-water tanks in both units have 500-watt tubular electric heaters attached to the outside. Surface themostats limit heater temperature to 185 F to prevent burnouts if tanks run dry. Tank capacity is 25 cups and recovery rate is 40 to 60 cups per hour.

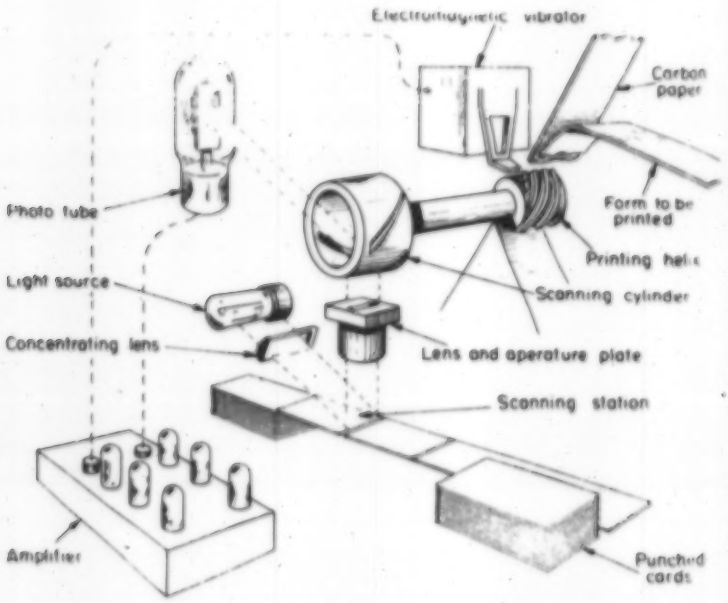
Optics and Electronics Combined in Facsimile Printers



ADDRESSES can be reproduced at a rate of 12,000 per hour by recently developed Addressograph-Multigraph Corp. facsimile printers. Ordinary punched cards on which names and addresses have been typed serve as the machine's source of information. The simplest machine imprints four-line address labels on a continuous paper strip. A second model will simultaneously print two strips. Another will print information on various types of preprinted forms such as bills, checks, notices or sales-promotion material.

Basic principles of the printer are illustrated by a simplified sketch. Punched cards bearing the names and addresses to be reproduced are fed through the machine. A light beam is projected on the cards and then reflected through a lens to a scanning cylinder. An optical system then projects the scanned beam to a photocell. Photocell output is amplified and then used to actuate an electromagnetic vibrator which forces a carbon paper strip and the paper to be imprinted against helical ridges on a small cylinder to make a dot or short line corresponding to the scanned portion of the input card.





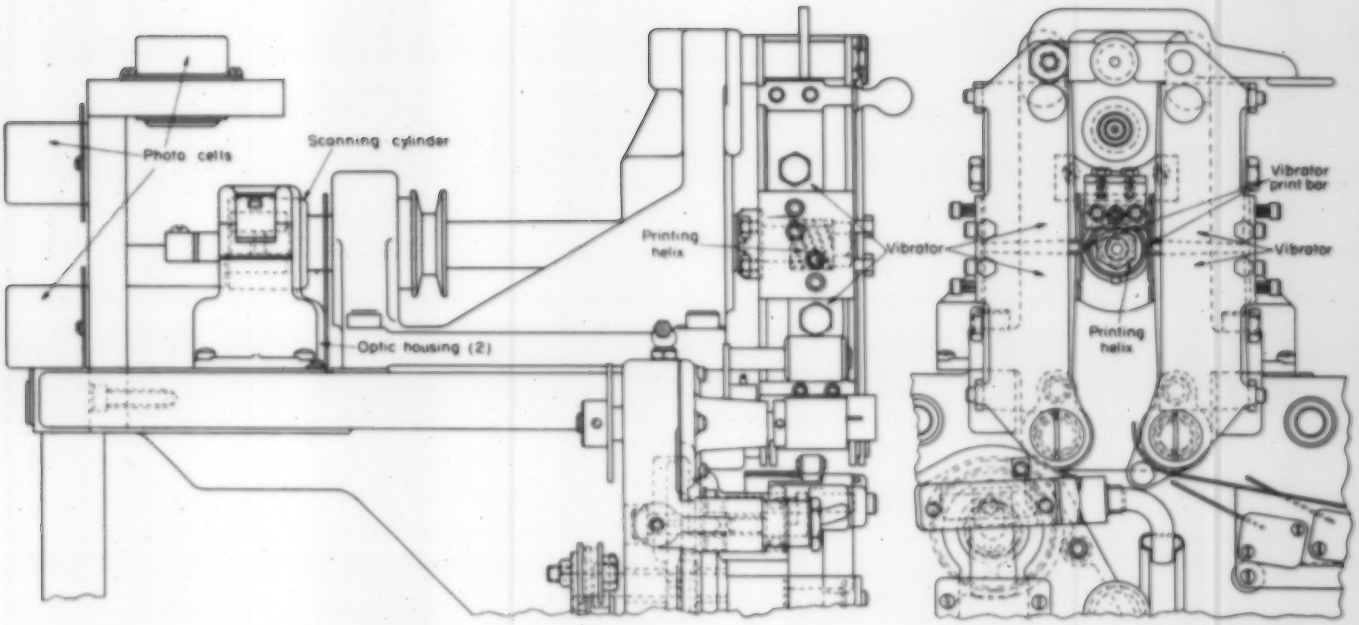
C C HARMON
654 N UNION
SHAWNEE OKLA
OK 7372 3GMB

XJA52

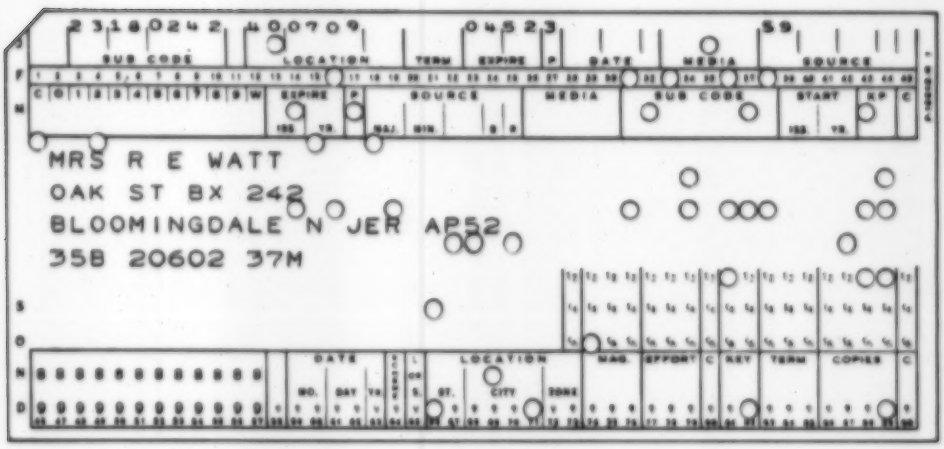
L C ARMSBY
R 1 BX 253
SAND SPRINGS OKLA MY53

MRS GEO M BECK JR
1002 WASHINGTON ST
SAND SPRINGS OKLA XJE52
2

CONTEMPORARY DESIGN



Actual practice is to use four photocells and four vibrators rather than the single units shown in the simplified sketch. This speeds up the printing rate since one vibrator and one photocell print one line while the others print the remaining three lines. A beam-splitting device is used to split light rays into four separate beams for actuation of the photo cells.



By G. W. Michalec*
Associate Section Head, General Precision Laboratory Inc., Pleasantville, N. Y.

PRECISION GEARING

BACKLASH in precision gear trains was analyzed in two preceding articles of this series. The second important defect of gears is inaccuracy, which will be studied and analyzed in this and a succeeding article. The coverage will be in two installments.

The primary function of gears is to transmit motion and power, which they successfully perform because of their inherent ability to operate with a constant velocity ratio. Gears have long been used in power applications where any appreciable variation in velocity ratio would result in severe dynamic loading due to acceleration and deceleration. However, the use of gears in precision instrumentation applications where precise positioning is of primary importance, has placed new and greater demands upon gear design and manufacture. Departures from ideal performance, which are negligible for ordinary commercial power operation, are often of much concern in the design of precision instrument gear trains and, also, for high-speed and high-load power applications.

Ability to determine and predict the relatively small position inaccuracies of precision gear trains is of considerable value to the designer. Such techniques eliminate doubtful design and the dependence upon final inspection test data for ultimate acceptance. Furthermore, if a rigorous and reliable analysis forms the basis of the design, the final product will have the best design. Inferior or over-design is thereby avoided.

The following analysis attempts to define and describe gear inaccuracy and its sources without use of higher mathematics, and to present a practical and simple method for predicting gear train inaccuracy.

Gear inaccuracy is defined as the degree of variation of velocity ratio from the theoretical nominal value. That is, although the gear has a whole number of teeth which fixes the velocity ratio in terms of integral numbers of turns, the instantaneous velocity ratio during the cycle of one revolution may fluctuate slightly. The variation in velocity ratio will result in corresponding displacement errors between meshed gears. Thus, gear inaccuracy can also be referred to as a *positional error* or *data transmission inaccuracy*. This error can be considered inherent or fundamental since it is nearly inevitably present to some degree in all gears.

Inaccuracy is not to be confused with backlash which is another fundamental type of gear malfunction. These two malfunctions are basically independent of one another. *Inaccuracy* here refers only to nonuniform motion due to fluctuating velocity ratio, and theoretically can occur with or without the presence of backlash. On the other hand, the presence of backlash does not affect conjugate gear action, as already discussed in Part 1 (January 1955). Thus, backlash and inaccuracy are independent, and a gear train can have either or both. *Inaccuracy* is not to be confused with the error in gear train position due to the lost motion of backlash. Although both cause positional errors, they have independent sources and affect gear action differently as will be shown in the following analysis. There are special cases when backlash and inaccuracy are interrelated and these will also be considered.

Theoretical analysis of inaccuracy might be best initiated by examination of a hypothetical illustration. Assume a perfect pinion is meshed with a gear having a perfect circular pitch circle, but its axis of rotation is displaced relative to the axis of the pitch circle. Thus, the gear, constituted by the pitch circles and base circle, is eccentric by some amount, say e. Such a defective gear meshed with a perfect pinion is shown in various positions in *Fig.* 24*a* through *d*. Only *Fig.* 24*a* is completely labeled, and the magnitude of eccentricity is exaggerated to clearly bring out its effects.

In *Fig.* 24*a* the perfect pinion and defective gear are meshed along a line passing through the center of the pitch circle of the defective gear. The

*Also Associate, Dept. of Mechanical Engineering, Columbia University, New York.

Part 3—Inaccuracy Sources and Their Evaluation

center of the pitch circle is displaced from the center of rotation by an eccentric amount, *e*. If the gear is rotated 90 degrees the new arrangement is shown in *Fig.* 24*b*. The center distance of rotation is fixed. However, due to the eccentricity, the instantaneous center distance of the base circles is increased and there is a new pitch point and larger pressure angle. A further rotation of 90 degrees, *Fig.* 24*c*, will bring the base circle center of the gear in line with the two centers of rotation. Now the instantaneous center distance of the base circles is a maximum and the pressure angle is also a maximum. An additional rotation of 90 degrees would yield a symmetrical duplicate of *Fig.* 24*b*, but with the center of the base circle below the center of rotation, *Fig.* 24*d*. A final rotation of 90 degrees would return the gear to the original condition, *Fig.* 24*a*.

It is evident that eccentricity between the pitch circle center and center of rotation causes several conditions:

1. The base circle center follows a circular path about the center of rotation.
2. The effective or instantaneous center distance of the base circles varies from a minimum value of (center distance of rotation minus *e*), to a maximum value of (center distance of rotation plus *e*).
3. The instantaneous pressure angle goes through a parallel variation from minimum to maximum.
4. The instantaneous pitch point traces an approximately circular path.

Geometry of these facts is partially plotted to an enlarged scale in *Fig.* 24*e*.

The foregoing variations occur continuously and smoothly with gear rotation, and for any given instant only one set of values of the variable parameters exist. Applying kinematic analysis, the instantaneous rate of rotation of the output pinion, or absolute gear ratio, is equal to the relative rotary motion between the two base circles plus vectorially the absolute motion of the gear base circle center (or pitch circle center) about the gear axis of rotation. The relative motion between the base circles is constant (constant gear

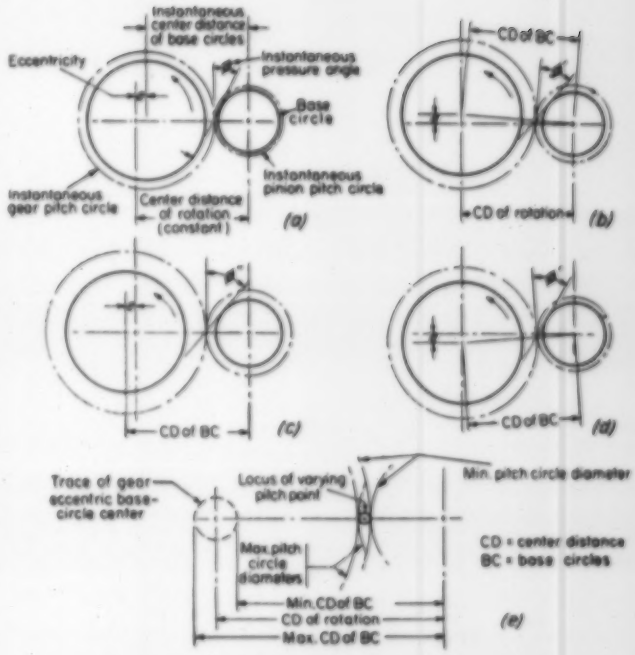


Fig. 24—Geometrical aspects of the mesh of an eccentric gear and perfect pinion. Sketches *a* through *d* show successive relationships throughout one rotation of the gear. Sketch *e* summarizes the actions

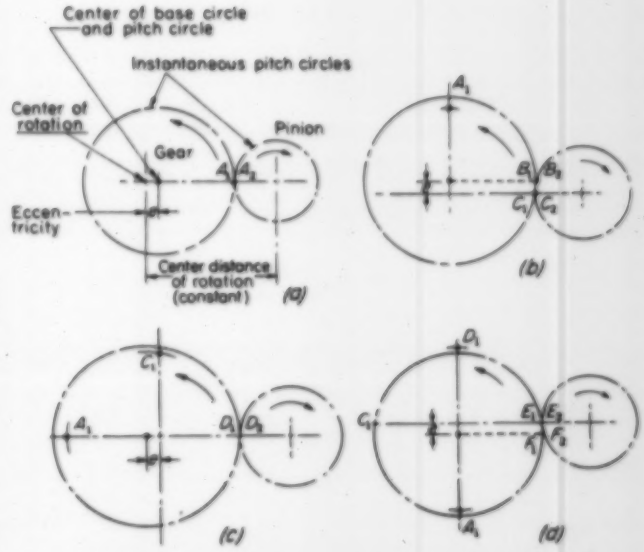


Fig. 25—Inaccuracy errors versus position in terms of pitch circle rotations

velocity ratio) because the base circle ratio has not been altered. However, the absolute motion of the base circle center about the axis of rotation is a translation motion and for vectorial addition only, its component along a normal to the line of centers imparts direct, although slight, rotary motion to the pinion. The sense of this motion alternates as the gear rotates. Thus, the pinion is driven with a constant rotary motion, which is the proper gear ratio, plus a superimposed oscillatory motion that is the error component or inaccuracy of transmission.

The true mathematical form of the error component is complicated and difficult to derive. Fortunately, there is a simple yet relatively accurate approximation which can be substituted.

In *Figs.* 25*a* through *d* the same gear pair is shown meshed in the same four special orientations of the axis of rotation and pitch circle center as pictured in *Fig.* 24. However, the drawings are simplified in that only the fixed line of centers and the instantaneous pitch circles are shown. Since the pitch circles vary in size, subsequent reference to angular measure between successive mesh points is to be considered as the angle between the radial lines containing these points.

In *Fig.* 25*a*, the ideal and defective driving gear are meshed with the pitch circle center of the defective gear lying on the fixed line of centers displaced from its center of rotation by an eccentric amount, e. Common points A_1 and A_2 of the respective gears are in mesh. In *Fig.* 25*b* the defective driving gear has been rotated counterclockwise 90 degrees relative to the original position, *Fig.* 25*a*. However, due to the eccentric center of rotation, point C_1 instead of B_1 is now on the line of centers. From the radial line containing A_1 to B_1 is 90 degrees of arc along the pitch circle. However, C_1 is displaced an additional amount due to the eccentricity. For small angles the chord can be assumed equal to the arc. Therefore, A_1C_1 is greater than A_1B_2 by e/R radians, if e is small relative to R, where R is the radius of the gear. Obviously, the driven pinion is positioned by the motion of the driving-gear pitch circle which in this case displaces the pinion by (e/R) times (gear ratio) radians greater than the input angle. Thus, the relative phasing of the meshed gears has undergone a continual advancing phase change from *Fig.* 25*a* to *b*. In the position of *Fig.* 25*c* the driving gear has rotated a total of 180 degrees, with the result that the pitch circle center is again in line with the line of centers, and the two gears are again in proper phase relationship. A further rotation of 90 degrees, *Fig.* 25*d*, shows the amount of arc of the driving gear pitch circle that has passed through the mesh to be less than 90 degrees by the amount e/R radians. That is, point E instead of point F is on the line of centers.

The result is that the driven pinion has rotated less than the driving gear by the amount (e/R) times (gear ratio) radians. This is a maximum amount of lag of the driven pinion. A further input of 90 degrees will result in the orientation of *Fig.* 25*a*, where both gears will be in phase again.

Thus, for one rotation of the eccentric driving gear, the driven output will advance and lag in positional relationship, and correspondingly the instantaneous velocity ratio will increase and decrease. *Fig.* 26 shows a plot of output inaccuracy error versus input angle. The actual curve form is approximately sinusoidal and for practical considerations can be assumed so.

The first derivative of the time-displacement curve yields the velocity curve. Therefore, for constant angular input the variation of output velocity will also be approximately sinusoidal, but the instantaneous maximum velocity error will be displaced 90 degrees from the corresponding maximum displacement error.

In summation, the presence of eccentricity between the gear center and the axis of rotation will cause a sinusoidal inaccuracy in the position of the driven pinion gear. The maximum magnitude of the inaccuracy is given by the following ac-

Fig. 26—Inaccuracy of output versus input angle of driving gear

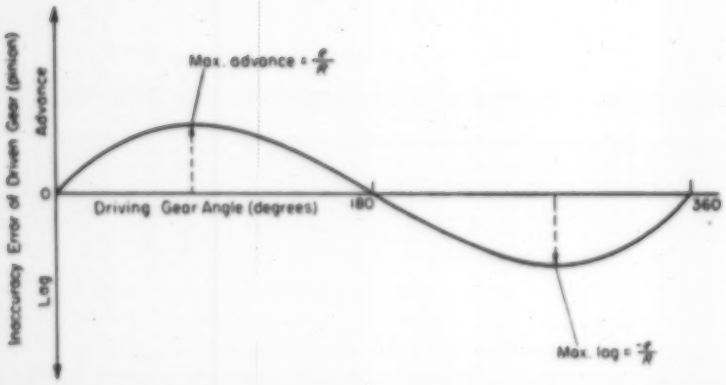
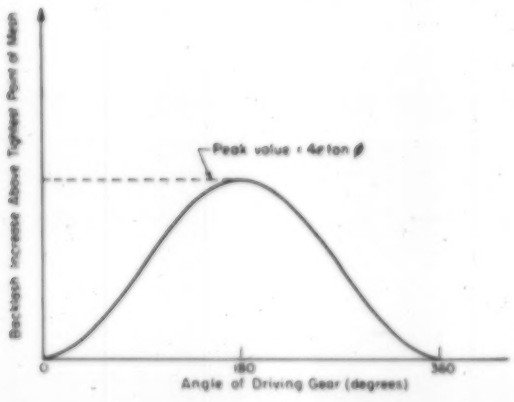


Fig. 27—Backlash increase of a meshed pair due to eccentricity of the driving gear



curate approximation: Maximum inaccuracy error of driven pinion gear equals $\pm(e/R)$ times the velocity ratio, or

$$E_s = \pm \frac{e}{R} \frac{R}{r} = \pm \frac{e}{r} \text{ radians} \quad \ldots\ldots (3)$$

where R = radius of gear, inches; r = radius of driven pinion gear, inches; and e = eccentricity, inches.

If the conditions of the foregoing example were so modified that the driven gear is eccentric and the driving gear perfect, a similar analysis could be made. The result would be the same in that the maximum inaccuracy error would be determined by means of Equation 3. Obviously, the problem would be generalized by assuming both gears of the pair to have eccentricity. This problem is more difficult in that the total error would depend upon the phase relationship of the eccentricities. This point will be considered later.

Interrelation of inaccuracy and backlash is evident. Eccentricity causes the gear teeth to work in and out of mesh; that is, the effective center distance of the gear centers changes in one rotation by an amount equal to twice the eccentricity. Obviously, backlash of the mesh varies with rotation.

Since backlash and inaccuracy are fundamentally different errors, in the foregoing inaccuracy analysis the variable backlash has been neglected and it has been implied that the meshed gear teeth lie in their mid or mean positions of backlash range. This is a realistic assumption, for in many applications, such as frequently reversing servo gear trains due to function or hunting, the mean position of the mesh will be the mid-backlash position. However, unidirectional drives and spring-loaded meshes behave differently and their special case is worthy of comment.

The variable backlash due to eccentricity is readily observed to be one cycle with rotation and varies approximately sinusoidally. A typical variable backlash curve is shown in *Fig.* 27, which is plotted for the gear pair used in *Figs.* 24 and 25. For this plot the zero angle reference of the driving gear is the tightest point of mesh, as for the previous figures, and therefore, the backlash increases from this point. The maximum backlash variation is obtained from the fundamental relationship between backlash and center distance change. In terms of eccentricity, it would be

$$B = 4\, e \tan \phi$$

where ϕ = pressure angle; e = eccentricity, inches; and B = linear backlash, inches.

Considering the special cases of unidirectional drives and loads, and spring-loaded gears, the driving tooth profile must always be in contact with the mating profile. As the backlash varies with rotation, the eccentric gear varies its positional or phase relationship with its mate. The phase of the eccentric gear will lag as the variable backlash increases from its minimum to maximum value and then the phase will advance as the cycle is completed. Thus, a plot of eccentric gear position versus inaccuracy error due to backlash is shown in *Fig.* 28. The curve is similar to the backlash curve of *Fig.* 27, since both are plotted with the same zero reference for driving gear angle.

For any position, the inaccuracy error due to variable backlash is equal to one-half the angular backlash value. The linear backlash, B, is obtained from the linear center distance change, as given by the foregoing equation. Therefore, the maximum inaccuracy error due to backlash variation is

$$E_B = \frac{1}{2} \frac{B}{R} = 2 \frac{e}{R} \tan \phi \quad \ldots\ldots (4)$$

This error due to variable backlash combines al-

Fig. 28—Inaccuracy component due to the variable backlash caused by eccentricity

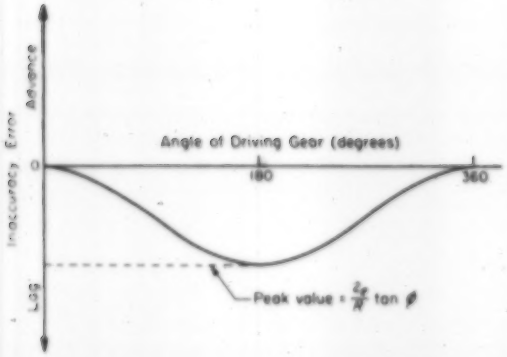
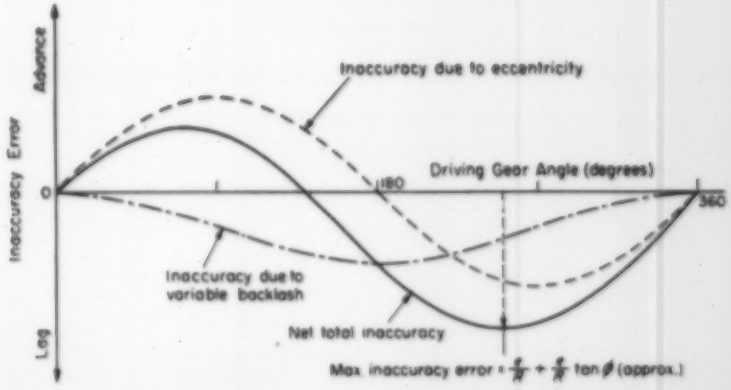


Fig. 29 — Total inaccuracy error versus angular position of eccentric driving gear for the case of a spring-loaded antibacklash mesh and/or unidirectional drives



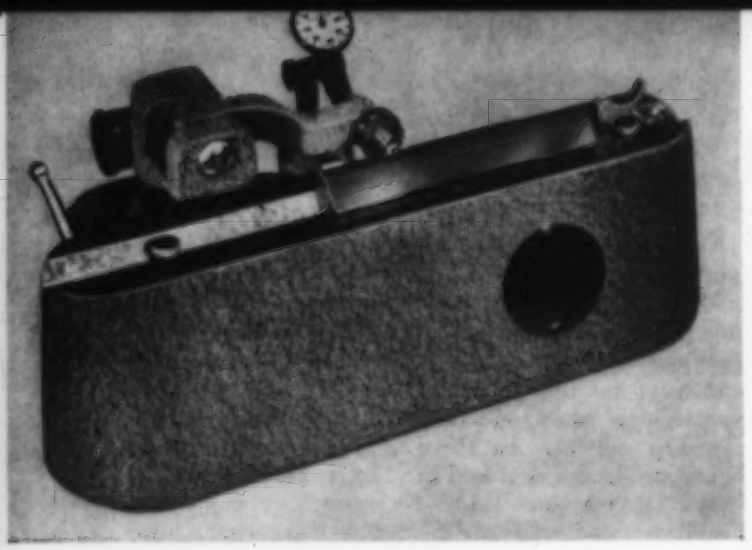


Fig. 30—A manual bench type conjugage tester, comparable in size and operation to the master gear tester shown in *Fig.* 4, *Part* 1, except for use of a precision worm section instead of a master gear

gebraically with the inaccuracy due to eccentricity previously analyzed to give the net inaccuracy. This combination is shown graphically in *Fig.* 29 which is obtained from a superposition of the curves of *Figs.* 26 and 28, plotted to a common scale.

From *Fig.* 29, it can be seen that the inaccuracy due to eccentricity is diminished by the effect of variable backlash for the first half-cycle of eccentric gear rotation. However, in the second half-cycle, the net inaccuracy is increased. Thus, the driven gear will have a greater peak lag angle than advance angle. The approximate maximum peak inaccuracy for spring-loaded gears or unidirectional drives will be

$$E_i = \frac{e}{R} + \frac{e}{R} \tan \phi \qquad (5)$$

As indicated, this is an approximate value being obtained merely by inspection of the curves of *Fig.* 29. Actually, the error is within 5 per cent for 20-degree pressure angle gears and even less for 14½ degrees.

Actual Sources of Inaccuracy

The foregoing approximate mathematical relationships between gear eccentricity and inaccuracy leads to indication and definition of the various sources of error as they actually occur.

For the previous academic analysis, it was convenient to assume an eccentric condition. Actually, this is a realistic assumption for in the manufacture and assembly of gear trains there are several sources of inaccuracy which resolve into simple eccentricities. These various inaccuracy components can be divided into two main groups: inherent gear inaccuracy and installation or assembly errors. They are all due to both machine and human limitations.

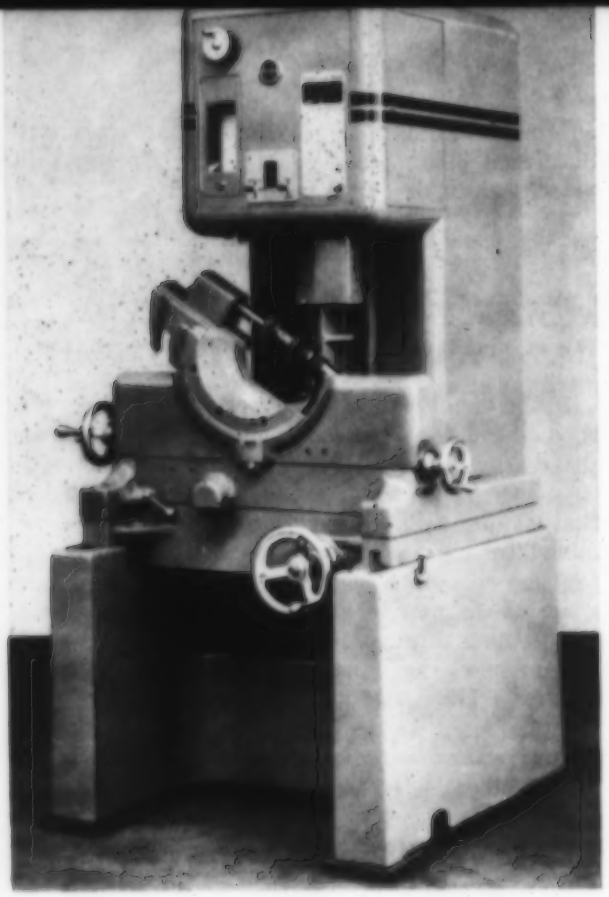


Fig. 31—Eastman-Kodak conjugage gear tester which utilizes a master worm section, approximating a rack, in intimate mesh with the gear being inspected. Variations in center distance are automatically plotted to a selected scale, from which total composite error and its components can be directly obtained

In the following brief description of each error source, it will be seen that these inaccuracy sources closely parallel the list established in *Part* 1 for sources of backlash components variable with rotation. This is logical, since eccentricities, regardless of their source, cause positional inaccuracy as well as variable backlash. Thus, these sources are re-examined here with particular regard to inaccuracy.

Inherent gear inaccuracy (total composite error) arises in the process of generating gear teeth because certain errors are unavoidable and become inherent. These errors can be controlled with extreme care but can never be entirely eliminated. There are four basic gear errors:

Pitch circle runout or pitch error, is the eccentricity of the gear bore and the pitch circle. Its inaccuracy effect has already been analyzed in this article.

Tooth thickness variation or spacing error is the variation of the circular pitch and directly affects accuracy of transmission.

Profile error is the discrepancy between the actual tooth form and the theoretical involute. Deviations from the involute result in velocity variation, and therefore inaccuracy, because of the nonfulfillment of the fundamental law of gearing.

Lateral runout or wobble of the pitch plane causes indirect profile error and also backlash which in special cases can contribute inaccuracy as already explained.

It can be seen that pitch circle runout and lateral runout are unicyclic with gear rotation, whereas tooth thickness variation and profile error occur from tooth to tooth although they need not occur at every tooth. Thus, if a plot were made of the errors in terms of the readings of a variable-center-distance inspection fixture, which gives the approximate pitch line variation with rotation, the unicyclic errors would approach a sinusoidal shape. Superimposed, and therefore modulating the curves, would be the tooth-to-tooth variations. Thus, a gear would have a net error curve which is the vector sum of the component curves. The overall variation, or deviation from the perfect pitch line is termed *total composite error*, and the tooth-to-tooth variations are lumped together as the tooth-to-tooth composite. The net error curve is directly obtainable as a plot or as indicator readings with variable-center inspection equipment. A typical sample curve of total composite error and its components is shown in *Fig.* 3, *Part* 1.

A measurement of inherent gear inaccuracy of fine-pitch gears can be obtained from conventional variable center distance inspection equipment such as those employing master racks, worm sections or gears. A typical manual device for this purpose is shown in *Fig.* 30. It should be pointed out that such devices give indirect total composite error curves, such as shown in *Fig.* 3, since the measurements are visual readings of a dial indicator. There are more elaborate testers which automatically record the center distance curve on a graph. Such a machine is pictured in *Fig.* 31. A typical curve plotted by this device is shown in *Fig.* 32. Note that this tester employs a master worm section (practically a rack) as the reference. This is considered to be a more precise method than master gear inspection, since racks or worm sections can be produced more accurately.

The inaccuracy effect from the total composite error can be approximated to an equivalent eccentricity error. Therefore, the maximum inaccuracy can be obtained from the previously derived formula by substituting one-half of the total composite error for the eccentricity. Thus, the maximum inaccuracy is equal to one-half the total composite error divided by the gear radius.

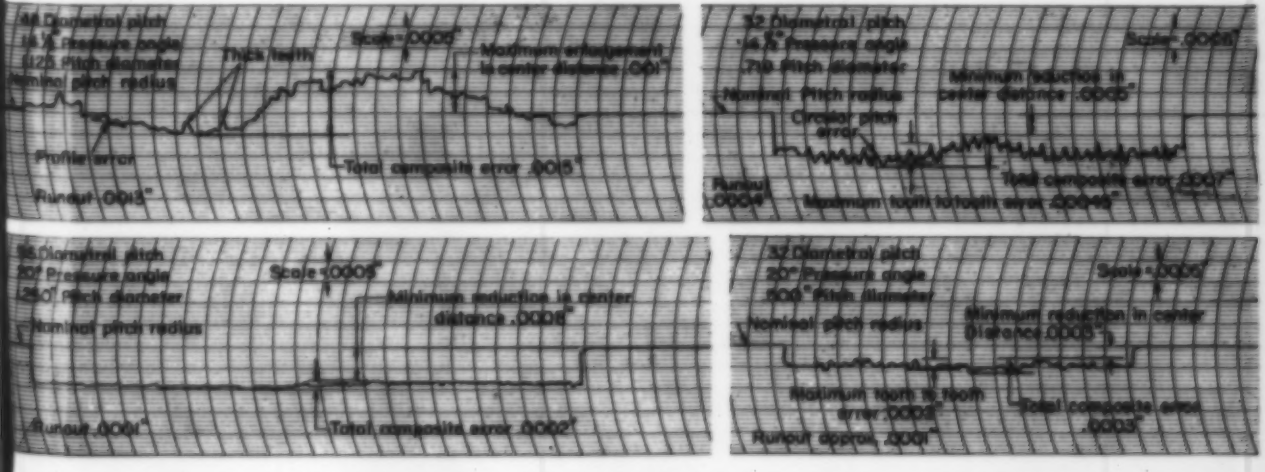
Total composite error (TCE) can be controlled within limits by specification of a maximum value on the gear drawing. Naturally, the application will dictate this value. However, to avoid a huge range of tolerances, total composite error is usually grouped into several classes or categories. The number and magnitude of the classes depends upon the type of gears and the applications for which they are intended. An idea of the range is given for fine pitch gears in *Table* 3, *Part* 1. The division there between so-called commercial and precision gears emphasizes the greater cost and special technique necessary to produce the more accurate ones.

Installation errors from six main sources are, in effect, eccentricity errors. They are:

GEAR MOUNTING ERROR results because the gear bore is usually made slightly greater than the mounting shaft diameter so as to allow for easy assembly. Thus, there is a small clearance, and when the gear is fastened, whether by key, pin, or set screw, the gear will be forced to one side. Even for split-hub clamped gears, the chances are the gear will be forced to one side. The result is that the gear pitch circle becomes eccentric by an amount equal to the radial clearance.

In addition, the gear bore and shaft diameter

Fig. 32—A sample gear curve of center distance variation as obtained on a tester identical to that shown in *Fig.* 31



must have reasonable manufacturing tolerances. Therefore, this source must be added to the minimum clearance to give a total effective eccentricity. As an illustration, *Table* 5, *Part* 1, lists clearances between shafts and gears based upon AGMA gear classes. Note there is a tie-in between tolerances and class, for obviously, the more accurate the gear class, the closer should be the tolerances on bore and shaft diameters. Otherwise, the good gear quality would be offset by poor assembly.

SHAFT ERRORS occur because of manufacturing imperfections in straightness and concentricity. Even centerless-ground shafting will have some bow. If the shaft is stepped, there will be runout between the gear mounting surface and the bearing. Thus, in the assembly, the gear will be thrown eccentric relative to its axis of rotation. *Table* 6, *Part* 1, lists typical runout figures for centerless shafting and stepped shafts produced by various methods.

COMPONENT ERROR is actually a variation of shaft error. If the gear is mounted on a component shaft such as a synchro, resolver or potentiometer, there will be runout error due to the errors in these assemblies. Maximum component shaft runout is usually specified by the manufacturer. *Table* 6, *Part* 1, lists typical values for various components.

BALL BEARING RUNOUT ERROR causes additional eccentricity error. *Table* 4, *Part* 1, lists the tolerances for the standard ABEC classes.

BEARING RADIAL PLAY ERROR exists for loaded gears which are reversing, and occurs regardless of whether the bearings are sleeve or ball type. The load causes the gear to force the shaft to one side, and then with reversal, the axis of rotation is slightly shifted.

Exceptions are spring-loaded gears or antibacklash gears, which are always loaded in both directions, and therefore the bearing reaction is fixed. Even though the radial play allows the shaft to shift to one side, the displacement remains fixed once the gear is spring-loaded and assembled. The result is that the radial play is inactive and does not contribute any inaccuracy.

BALL BEARING SHAFT AND HOUSING CLEARANCE FITS is a source of error similar to bearing radial play. It arises from any appreciative clearance between the inside diameter of the ball bearing and the shaft diameter and, also, the outside diameter of the ball bearing and the housing bore. Ideally, there should be no clearance, but interference fits would be required with the risk of too much bearing squeeze-in. Therefore, if there is a clearance, reversing gear action will cause the center of the gear-shaft assembly to shift from one side of the clearance to the other, resulting in inaccuracy error. Fortunately, this source can often be neglected because many precision gear trains have selective line-to-line fits and, in addition, the tooth loads are so low that little "slopping" occurs. However, if loads are high and clearances excessive, this would be a source to consider. Again, for spring-loaded applications or unidirectional drives, this error source would be eliminated.

Evaluation of inaccuracy sources is important because the foregoing error sources differ in relative magnitude and ease with which they can be controlled. Basically, they are all equally important because they directly affect accuracy as an eccentricity. They only differ in magnitude, which in turn is related to the difficulties of manufacture.

The inherent inaccuracy of the gear—total composite error—is the most important single error source, although the sum of installation errors may be greater. Once a gear is made, it will always have its inherent total composite error, and no amount of installation care can remove it. Usually, its magnitude is greater than any of the other sources.

Among the installation sources, the gear mounting error is usually most important because of its magnitude. However, for a gear mounted upon a component shaft, it is possible for its error to be equally or even more important. Shaft errors, bearing runout, and bearing radial play are usually small error sources and for many applications can even be neglected.

Thus two, or possibly three, error components are very significant, and the balance are of only minor importance.

Interrelation of inaccuracy sources occurs in their effects rather than in their causes. As sources, they are independent of one another since they arise from individual fabrication processes. The independence refers to both the magnitude of the error and angular orientation of the equivalent eccentricity. However, the effects of the various error sources are not independent of one another. Sources with their eccentricities in the same angular direction add error effects, whereas eccentricities 180 degrees out of phase are subtractive, and orientations between these extremes have proportional effects.

Next month this series of articles will be concluded with an analysis of how maximum and probable inaccuracies are calculated. Numerical examples and a survey of methods for reducing inaccuracy will be presented.

They Say . . .

"It has been estimated that Russia is turning out two or three times as many engineers as we. We must, therefore, be two or three times as creative as Russia's engineers."—C. G. A. ROSEN, *president, Caterpillar Tractor Co.*

KNURLING

By C. T. Appleton
Vice President
Reed Rolled Thread Die Co.
Worcester, Mass.

KNURLING is most commonly used for decorative purposes and for serrating surfaces where components are locked or keyed together in unit assemblies. The term *knurling* designates both the process and the knurled portion of the work. Knurling is obtained by displacement of the material when the knurl is pressed against the surface of a rotating work blank. Knurling tools are used for producing straight, diagonal or diamond knurling having teeth of uniform pitch on cylindrical surfaces.

Cylindrical knurls are used for knurling on screw machines, automatic lathes and cylindrical-die thread-rolling machines. The most commonly used knurls are those which produce straight, diagonal and diamond patterns on the work, *Fig.* 1. Special knurls may be used, however, to produce teeth on tapered, convex or concave surfaces, *Fig.* 2. Flat knurling dies are used in reciprocating types of thread rolling machines.

Diamond knurling may have either a male or female pattern. Male diamond knurls have raised points and produce a female impression. Female diamond knurls have depressed points and produce a male impression. The male diamond pattern knurling with raised points on the work is most commonly used since it can easily be produced by using two diagonal knurls—one right-hand and the other left-hand. Single knurls with male or female diamond patterns are also used.

Tooth Form: A knurled tooth is V-shaped and the depth of the tooth is less than the depth of a theoretical V-form, *Fig.* 3. The tooth has a rounded root and crest. The relationship between the actual depth of tooth to the theoretical V varies with the pitch of the teeth. On finer pitches, the tooth is a smaller proportion of the theoretical

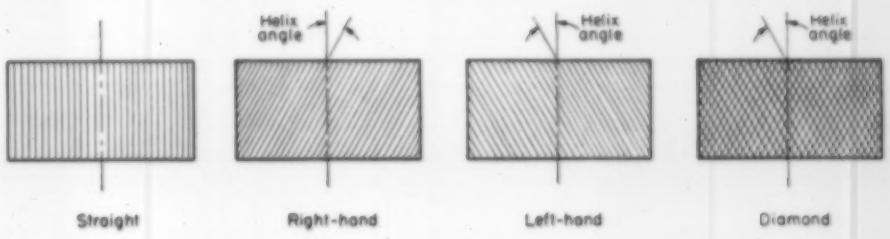


Fig. 1 — Common types of knurling

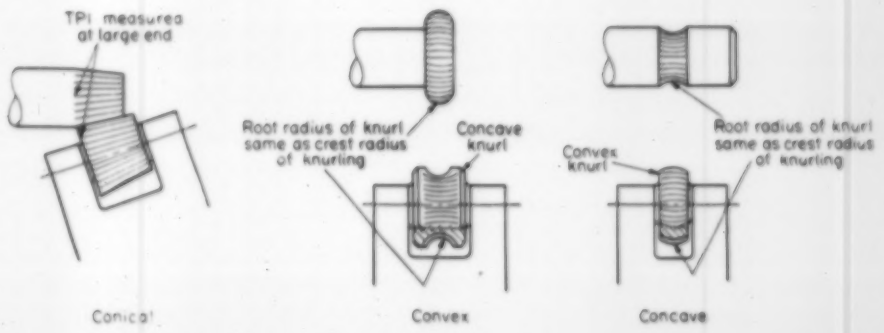

TPI measured at large end
Root radius of knurl same as crest radius of knurling
Concave knurl
Convex knurl
Root radius of knurl same as crest radius of knurling
Conical
Convex
Concave

Fig. 2—Types of special knurling

Table 1—Knurling Methods

Knurling Produced from Cross Slide—One Knurl

Type of Feeding	Knurls Used: Straight	LH Diagonal	RH Diagonal	Female Diamond
In-Feed with side knurl holder (Knurl, Work)	Straight	RH Diagonal	LH Diagonal	Male Diamond (raised points)
In-Feed with top knurl holder (Knurl, Work)	Straight	RH Diagonal	LH Diagonal	Male Diamond (raised points)
In-Feed with bottom knurl holder (Knurl, Work)	Straight	RH Diagonal	LH Diagonal	Male Diamond (raised points)

Knurling Produced from Cross Slide—Two Knurls

Type of Feeding	Knurls Used: Straight	LH Diagonal	RH Diagonal	R&LH Diagonal
In-Feed with side knurl holder (Knurl, Work)	Straight	RH Diagonal	LH Diagonal	Male Diamond (raised points)
In-Feed with adjustable straddle type holder (Knurl, Work)	Straight	RH Diagonal	LH Diagonal	Male Diamond (raised points)

Knurling Produced from Turret—One Knurl

Type of Feeding	Knurls Used: Straight	LH Diagonal	RH Diagonal	Female Diamond
In-Feed with swing type knurl holder actuated from cross slide (Knurl, Work)	Straight	RH Diagonal	LH Diagonal	Male Diamond (raised points)

Knurling Produced from Turret—Two Knurls

Type of Feeding	Knurls Used: Straight	LH Diagonal	RH Diagonal	R&LH Diagonal
In-Feed with swing type knurl holders. In-feed actuated from cross slide (Knurl, Work)	Straight	RH Diagonal	LH Diagonal	Male Diamond (raised points)
End-Feed with adjustable knurl holder actuated from cross slide (Knurl, Work)	Straight	RH Diagonal	LH Diagonal	Male Diamond (raised points)
End-Feed with adjustable knurl holder (Knurl, Work)	Straight	RH Diagonal	LH Diagonal	Male Diamond (raised points)
End-Feed with adjustable swivel type knurl holder (Knurl, Work)	Male Diamond (raised points)			
End-Feed with adjustable swivel type knurl holder (Knurl, Work)	R or LH Diagonal (RH diagonal shown)			

Table 2—TPI and Circular Pitches

(for diagonal and diamond knurling with 30-degree helix angle)

TPI (teeth per inch)		Circular Pitch (inches)	
Normal	Transverse	Normal	Transverse
12	10.39	0.0833	0.0962
16	13.86	0.0625	0.0722
19	16.45	0.0526	0.0607
20	17.32	0.0500	0.0577
24	20.78	0.0417	0.0482
25	21.65	0.0400	0.0462
29	25.11	0.0345	0.0398
30	25.98	0.0333	0.0385
35	30.31	0.0286	0.0330
40	34.64	0.0250	0.0289
41	35.51	0.0244	0.0282
47	40.70	0.0213	0.0246
50	43.30	0.0200	0.0231
80	69.28	0.0125	0.0144

V-depth than on coarser pitches. Also, female diamond patterns have shallower tooth depth than male diamond patterns.

Pitch Systems: Two general methods of knurling are now in use—the circular-pitch and the diametral-pitch systems. The circular-pitch system is the older and has been in use for many years. It is based on the circular pitch and teeth-per-inch formulas related to the circumference of the work.

The diametral-pitch system is covered by ASA B5.30-1953. Four standard diametral pitches, 64, 96, 128 and 160, are used for work diameters ranging from 3/32 through 1 inch. The purpose of diametral pitch knurling is to permit work blank diameters of standard fractional stock sizes to be used. The 96 and 160 diametral pitches apply to work blank diameters in 1/32-inch diameter increments and the 64 and 128 diametral pitches are for work blank diameters in 1/64-inch diameter increments.

Knurling Methods: Sequence of operation and tooling for knurling are dependent upon the nature of the part and type of equipment selected. Knurling tools on automatic lathes and screw machines are mounted on the cross slides or in the turrets for either in-feed or end-feed knurling, depending upon the type of knurling and the knurl holders used.

Both one and two knurls are used for in-feed knurling, while two knurls are always necessary for end-feed knurling. The method of feeding the knurl into the work varies with the position of the knurling on the work with respect to shoulders, the type of knurl holder, and the position of the holder on the machine. The common methods of applying the knurls are illustrated in *Table* 1.

Circular-Pitch Knurling: Knurling by this system is related to the distance between the teeth on the circumference of the work blank. It is usually expressed in terms of the number of teeth per inch, TPI.

When knurling is used for decorative and general appearance purposes or for hand grip, only the approximate teeth per inch, TPI, need be specified, thereby permitting standard knurls to be used.

The tooth pattern of the knurling—straight, diagonal or diamond—whether diamond pattern is male or female, and helix angle should always be specified. Knurling is sometimes referred to as coarse, medium and fine. Where no reference is made to diameters, 16-20 TPI is sometimes referred to as coarse, 25-35 as medium and 40-80 as fine. Much confusion has resulted from this practice because the size of the knurled diameter, in many instances, influences the selection of the pitch of the knurl to be used. What appears to be a coarse pitch on a small diameter may seem like a medium or fine pitch on a large diameter. It is therefore recommended that the knurling be specified on the basis of teeth per inch. *Table* 2 shows the corresponding circular pitches for the different numbers of teeth per inch (TPI) in terms of normal pitch and transverse pitch for diagonal and diamond knurling with a helix angle of 30 degrees.

In general practice, the depth of tooth of the knurling provided with standard circular-pitch knurls approximates the following percentages of circular pitch on straight knurling or normal circular pitch on diagonal and diamond knurling:

Straight teeth	35
Diagonal teeth	35
Diamond pattern:	
Male	40
Female	25

Knurled diameters and the circular pitch of the knurl are related. The circumference of the work blank should be an approximate multiple of the circular pitch for straight knurling and transverse circular pitch for diagonal and diamond knurling. Blank diameters vary with the circular pitch of the knurling selected, and should only be specified after the proper diameter of blank is determined by experimentation.

KNURLED DIAMETERS: The approximate increase in blank diameters when using knurls for different numbers of teeth per inch with straight, diagonal and diamond pattern knurling is shown in *Table* 3.

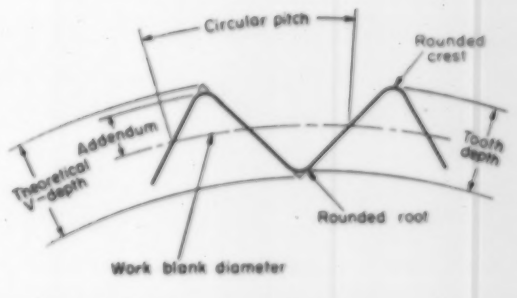


Fig. 3—Knurling tooth form

Table 3—Approximate Increase of Blank Diameters

Teeth per Inch*	Straight and Diagonal† Knurling	Diamond Knurling† Male (raised points)	Diamond Knurling† Female (depressed points)
12	0.029	0.028	....
16	0.022	....	....
20	0.018	0.020	0.012
25	0.014	0.016	0.010
30	0.012	0.013	0.008
35	0.010	....	....
40	0.009	0.010	....
50	0.007	0.008	0.005
80	0.004	0.005	....

*Refers to normal teeth per inch on diagonal and diamond knurling.

†With 30-degree helix angle.

Table 4—Suggested Minimum Knurled Diameters

TPI* (teeth per inch)	Standard Width of Knurl Face (in.) 3/16	1/4	3/8
16	.....	13/32	1/2
20	5/16	11/32	7/16
25	1/4	9/32	3/8
30	7/32	1/4	5/16
35	3/16	7/32	9/32
40	5/32	3/16	1/4
50	1/8	5/32	7/32
80	5/64	7/64	11/64

For in-feed rolling on general applications. Based on rolling conditions satisfactory for knurling and work being rigid and properly supported.

*Refers to normal TPI on diagonal knurling.

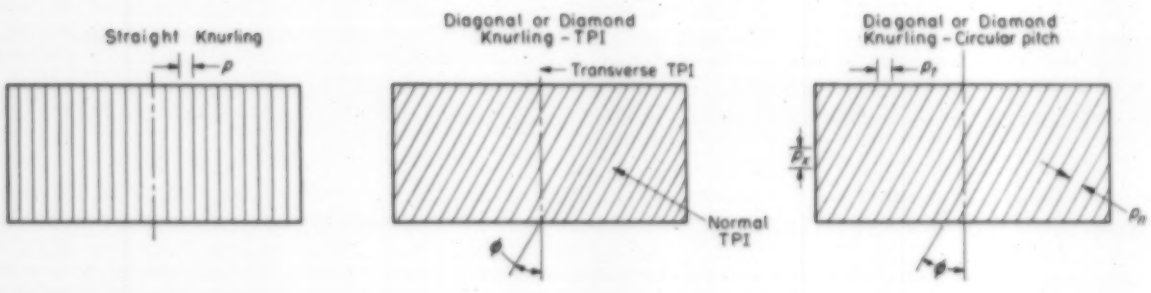
The amount of increase shown is based on knurling soft steels and is a guide only. The amount of increase varies slightly with different materials.

Care should be exercised not to specify knurled diameters with too few teeth. Consideration should be also given to the length of the knurling and the pressure required to force the knurl into the work. Greatest pressures are exerted by the coarser pitches and with in-feed knurling using single knurls. Wide knurls require more pressure than narrow knurls. *Table* 4 may be used as a guide in selecting the smallest knurled diameters to use for knurling with different numbers of teeth per inch and widths of knurl faces.

KNURLING TOLERANCES: For general-purpose knurling of good quality, the limits and tolerances of the knurled diameters are relatively unimportant and need not be specified. However, where it is necessary to specify tolerances and limits on knurled diameters for general-purpose knurling, the tolerances may be expressed as 30 to 50 per cent of the circular pitch, with about 75 per cent of the tolerance in a minus direction. Liberal tolerances should be used to keep manufacturing cost low. For precision straight knurling, where components are to fit together, the tolerances may be reduced to approximately 15 to 20 per cent of the circular pitch of the knurling and the tolerances should be in the minus direction.

WORK BLANK DIAMETERS: Since the knurls penetrate and reform the surface of the blank, they do not remove or compress material. The material is

Fig. 4—Knurling details for circular-pitch system



$$N_W = \frac{3.1416\,D_W}{p}$$

$$T = \frac{N_W}{3.1416\,D_W}$$

$$D_W = \frac{p\,N_W}{3.1416}$$

$$N_W = 3.1416\,D_W\,T_t$$

$$= 3.1416\,D_W\,T_n\cos\phi$$

$$T_t = \frac{N_W}{3.1416\,D_W}$$

$$= T_n\cos\phi$$

$$T_n = \frac{N_W}{3.1416\,D_W\cos\phi}$$

$$= \frac{T_t}{\cos\phi}$$

$$N_W = \frac{3.1416\,D_W}{p_t}$$

$$= \frac{3.1416\,D_W\cos\phi}{p_n}$$

$$D_W = \frac{p_t\,N_W}{3.1416}$$

$$= \frac{p_n\,N}{3.1416\cos\phi}$$

Nomenclature

D_K = Knurl outside diameter, inches
D_W = Theoretical work blank diameter, inches
N_K = Number of teeth on knurl
N_W = Number of teeth on work
P = diametral pitch, teeth per inch of diameter
p = Circular pitch, inches = $1/T$
p_n = Normal circular pitch, inches
p_t = Transverse circular pitch, inches
p_x = Axial pitch, inches
T = TPI, number of teeth per inch on circumference of work blank diameter = $1/p$
T_n = Normal TPI, teeth per inch
T_t = Transverse TPI, teeth per inch
ψ = Angle between knurl axis and work axis
ϕ = Helix angle

simply squeezed out of the roots of the serrations and is formed up into the crests, resulting in an increase in outside diameter. It is important, therefore, that the work blank does not contain more than the correct amount of material required to form the finished knurled diameter. Otherwise, the knurls will become overloaded and excess pressures will be exerted on both the tools and equipment if attempts are made to reduce oversize knurled diameters when too large blanks are used.

The knurled diameter is larger than the unknurled blank by an amount approximately equal to the tooth depth of the knurl used. Blank diameters for knurling are therefore approximately equal to the knurled diameter minus the depth of tooth. Since variation in the blank diameter results in variation of knurled diameter, it is necessary that the blank diameter tolerances be controlled according to the accuracy of the knurling to be produced. Uniformity of blanks is required to produce uniform knurling.

Diameter of the blank has a definite relation to the proper tracking of the knurl on its original contact with the work. The circumference of the work blank should be an approximate multiple of the circular pitch of straight knurls and the transverse circular pitch of diagonal knurls. With improper blank diameters, the teeth of the knurl as they continue to feed into the work fail to mesh with the indentations made during the first revolution of the blank. Blanks for straight knurling should be free of taper and the surface of the blank reasonably smooth. Blank diameters also differ with knurling conditions such as materials and variations of practice.

Improper and varying blank diameters result in reduced knurl life, poor finish, double teeth, uneven tooth profile, and inability to obtain uniformity of number of teeth and knurled diameter on the work.

There are many variations entering into the knurling that make it difficult to establish a formula that will accurately predetermine exact blank diameters. The formulas in *Fig. 4* may be used, however, for determining a theoretical work blank

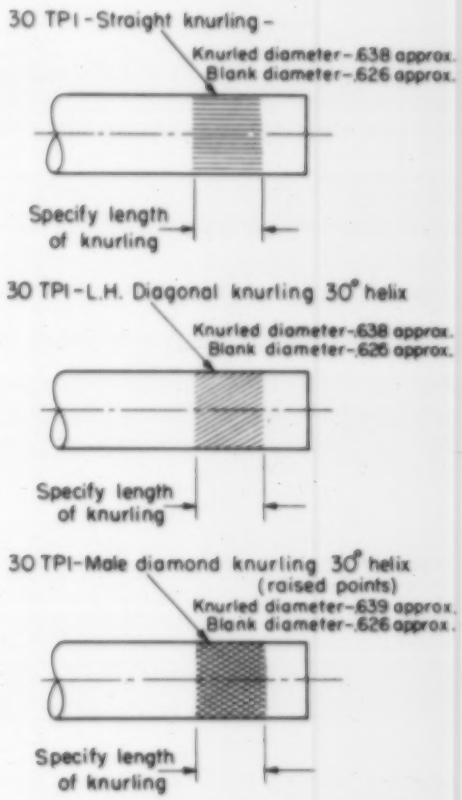

30 TPI - Straight knurling -
Knurled diameter - .638 approx.
Blank diameter - .626 approx.
Specify length of knurling
30 TPI - L.H. Diagonal knurling 30° helix
Knurled diameter - .638 approx.
Blank diameter - .626 approx.
Specify length of knurling
30 TPI - Male diamond knurling 30° helix
(raised points)
Knurled diameter - .639 approx.
Blank diameter - .626 approx.
Specify length of knurling

Fig. 5——Recommended drafting practice for circular-pitch system of knurling

Table 5—Diametral-Pitch Knurling

Diametral Pitch	TPI* (teeth per inch, approx)	Circular* Pitch (in.)	Approx Depth of Tooth or Increase of Blank Diameter (in.) Straight	Diagonal	Min No. of Teeth in Knurled Circumference	Work Blank Diameters (in.) Range	Diameter Increments
64†	20.4	0.0491	0.024	0.021	24	3/8–1	1/64
96	30.6	0.0327	0.016	0.014	24	1/4–1	1/32
128	40.7	0.0245	0.012	0.010	18	9/64–1	1/64
160	50.9	0.0196	0.009	0.008	15	3/32–1	1/32

*Refers to transverse TPI and transverse circular pitch on diagonal knurling.

†Use of 64 diametral pitch should be avoided as much as possible. For simplification of tools preference should be given to 96 diametral pitch. In the case of diamond knurling, the amount of raised pattern on the work should be specified.

diameter, or obtaining the circular pitch and number of teeth that may be rolled on a blank of a specified diameter. Formulas apply to in-feed and end-feed knurling. The transverse circular pitch, p_t, is used for diagonal and diamond knurling.

Tolerances for work blank diameters vary with the knurling requirements. For general purpose knurling the tolerances usually range between 5 to 8 per cent of the circular pitch, and for precise knurling, approximately 2 to 4 per cent of the circular pitch.

Example **1: Determine the approximate blank diameter for rolling 60 straight teeth on a knurled surface with a 20 TPI knurl.**

$$D_a = \frac{p\,N_W}{3.1416} = \frac{1}{20}\,\frac{60}{3.1416} = 0.955\text{-inch}$$

Example **2: Determine the approximate number of diagonal teeth that can be rolled on a blank 0.625-inch in diameter with a 30 normal TPI knurl having a 30-degree helix angle.**

$$N_W = \frac{3.1416\,D_W \cos\phi}{p_n} = \frac{3.1416(.625)(.866)}{\frac{1}{30}}$$

$$= 51 \text{ teeth}$$

A proportional formula frequently used for selecting the diameter and number of teeth on a knurl to produce a specified number of teeth on a given work blank diameter is

$$\frac{D_W}{N_W} = \frac{D_K}{N_K}$$

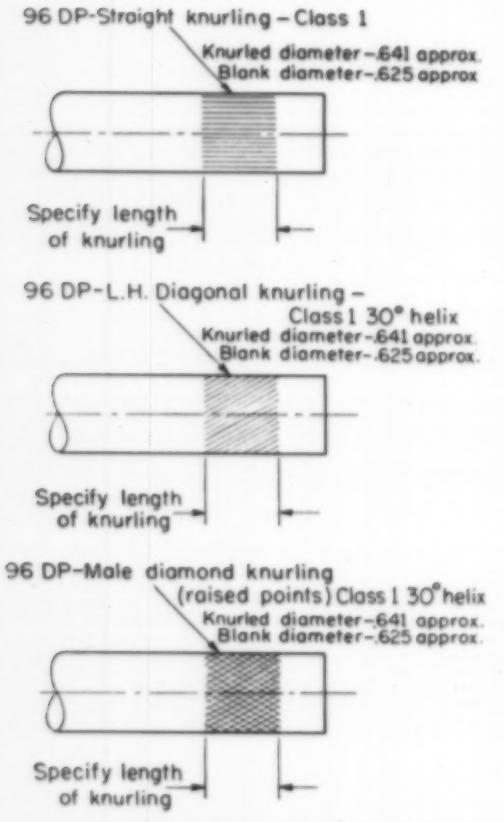

96 DP-Straight knurling – Class 1
Knurled diameter–.641 approx.
Blank diameter–.625 approx
Specify length of knurling
96 DP-L.H. Diagonal knurling – Class 1 30° helix
Knurled diameter–.641 approx.
Blank diameter–.625 approx.
Specify length of knurling
96 DP-Male diamond knurling (raised points) Class 1 30° helix
Knurled diameter–.641 approx.
Blank diameter–.625 approx.
Specify length of knurling

Fig. 6—Recommended drafting practice for diametral-pitch system of knurling

Dimensioning of Circular-Pitch Knurling: For general purpose knurling, only limited dimensions are necessary, *Fig.* 5. The designer should always allow leeway in dimensioning knurled diameters so the setup men may experiment in establishing the exact relationship between the work blank diameter and the diameters on the finished knurled product.

Allowance for variation in number of teeth in the knurled diameter should also be made unless the use of the knurled surface demands an exact number of teeth made to a prescribed form. In such cases, precise limits on blank diameters will be required and these limits can only be determined by experimentation with precision knurls for the specific material and work to be knurled.

Diametral-Pitch Knurling: According to ASA B5.30-1953, the four standard diametral pitches available are 64, 96, 128 and 160. The 96 and 160 diametral pitches are for blank diameters having fractional increments of 1/32-inch and the 64 and 128 diametral pitches are for blank diameters having fractional increments of 1/64-inch. The American Standard recommends that the use of the 64 pitch should be avoided as much as possible, and for simplification of tools, preference be given to the use of 96 pitch.

The term diametral pitch applies to the quotient of the total number of teeth in the circumference of the work divided by the basic diameter of the work blank. The diametral pitch is the ratio of the number of teeth on the work to the number of inches of basic work blank diameter and equals the number of teeth to each inch of basic blank diameter. That is.

$$P = \frac{N_W}{D_W}$$

The diametral pitch and the number of teeth are

Table 6—Recommended Knurled OD Tolerances

Diametral Pitch	Class I	Class II	Class III
64	+0.005 −0.012	+0.000 −0.010	+0.000 −0.006
96	+0.004 −0.010	+0.000 −0.009	+0.000 −0.005
128	+0.003 −0.008	+0.000 −0.008	+0.000 −0.004
160	+0.002 −0.006	+0.000 −0.006	+0.000 −0.003

always measured in a transverse plane which is perpendicular to the axis of rotation for diagonal as well as straight knurling.

A comparison of diametral pitches, TPI, and circular pitches is shown in *Table* 5.

Diagonal and diamond knurling on work blanks may be accomplished by setting the axes of straight knurls at an angle to the work axis. When straight knurls are used to produce diagonal and diamond knurling by end-feeding, the transverse diametral pitch that is produced on the work will not be the same as that of the knurl. The diametral pitch in such instances refers to the diametral pitch on the knurl rather than the knurling produced on the work.

KNURLING TOLERANCES: The American Standard for straight and diagonal knurling applies to work blank diameters up to 1 inch and includes three classes of tolerances, *Table* 6. These classes and recommended applications are:

Class I. Tolerances in this classification may be applied to straight, diagonal and raised diamond knurling where the knurled outside diameter of the work need not be held to close dimensional tolerances. Such applications include knurling for decorative effect, grip on thumbscrews, and inserts for moldings and castings.

Class II. Tolerances in this classification may be applied to straight knurling only and are recommended for applications requiring closer dimensional control of the knurled outside diameter than provided for by Class I tolerances.

Class III. Tolerances in this classification may be applied to straight knurling only and are recommended for applications requiring closest possible dimensional control of the knurled outside diameter. Such applications include knurling for close fits.

WORK BLANK DIAMETERS: The formula for theoretical work blank diameters is:

$$D_W = \frac{N_W}{P}$$

For end-feed knurling with straight-tooth knurls,

$$D_W = \frac{N_W}{P \cos \psi}$$

The number of teeth produced on the work blank is measured in the transverse plane and may be determined with the following formula for diagonal knurling:

$$N_W = D_W P \cos \psi$$

Example 3: If 30-degree diagonal knurling were to be produced on 1-inch stock with a 96 diametral pitch straight knurl,

$$N_W = D_W P \cos \psi = 1.000\ (96)\ (.866)$$

$$= 83.14 \text{ teeth}$$

Increasing the angle between the knurl axis and the work axis to approximately 30¼ degrees would provide good tracking of the knurl and make it possible to obtain an even 83 teeth instead of 83.14. By reducing the diameter of the work blank to a decimal size, good tracking of the knurl can be obtained for 30-degree diagonal knurling. That is

$$D_W = \frac{N_W}{P \cos \psi} = \frac{83}{96(.866)} = 0.998\text{-inch}$$

The tolerances for work blank diameters vary with the knurling requirements. For general-purpose knurling the tolerances usually range between 5 to 8 per cent of the circular pitch and for precise knurling, approximately 2 to 4 per cent of the circular pitch.

DIMENSIONING OF DIAMETRAL-PITCH KNURLING: In general, the same remarks made with respect to circular-pitch knurling also hold for diametral-pitch knurling. Recommended drafting practice is shown in *Fig.* 6.

---

industrial design Ideas

round the corner

HERE's an idea on industrial design that any engineer can use. It's a twist that not only will improve the looks of any product but will reduce costs all the way from original design through manufacture. It's simply this: *Pick out a couple of corner radii (not more than three) and stick to them throughout the design!*

I recently had the problem of redesigning a small bench machine which practically solved itself by the use of this simple formula. We picked out ¼ and 3-inch radii and

applied them. Looks of the product were instantly improved, the design simplified, and cost minimized.

Most products are complicated enough in their basic shape without being further complicated by dozens of radii chosen at the whim of every engineer involved in the project.

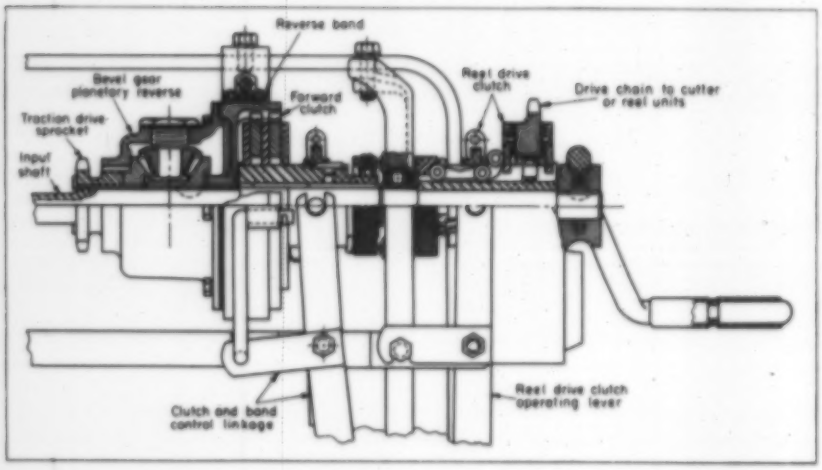
Why not add a new "Standards Sheet" in your engineering book covering radii so they will automatically enhance, rather than detract from, the appearance of your products—and also help give your products a family resemblance?

—*Cliff*

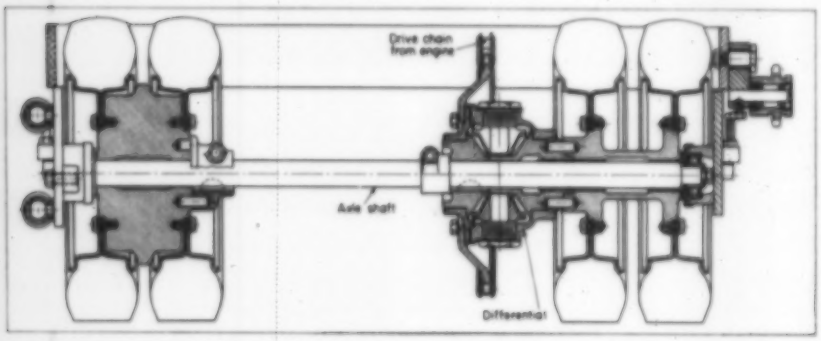
Power Mower Has Electric Starting

A RECENTLY introduced power lawn mower has an electric starter. According to the manufacturer, Toro Mfg. Corp., this is the first time an electric starter has been used for this purpose. Other features of the new Professional Model mower make it virtually a grass-cutting automobile. Riding sulky, forward and reverse gears, dual pneumatic tires and a differential are used. Three mowing units, each power driven, may be adjusted to mow a swath from 30 to 76 inches wide. This capacity fits the mower for use primarily in parks, golf courses or estates having wide expanses of grass.

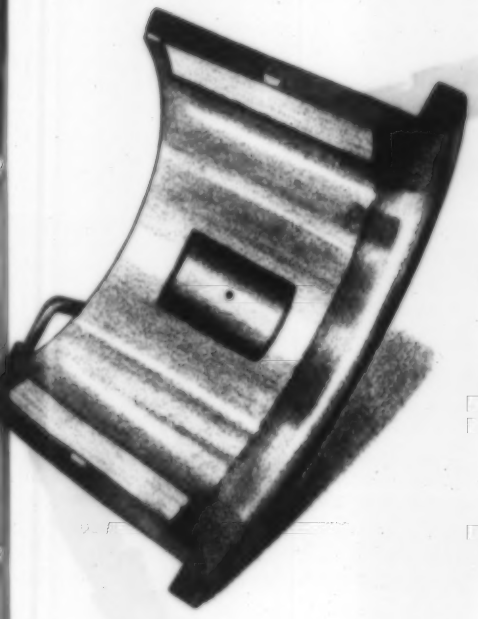
Traction drive system employs a planetary bevel gear reverse. Tightening the reverse band and disengaging the forward clutch causes the traction drive sprocket to rotate in a direction opposite that required for forward travel. With the band loose and forward clutch engaged, the mower moves forward. The forward clutch is disengaged and the band is loose in neutral position. One lever with three positions controls band and clutch. As a safety measure, the lever must be held in reverse position; it automatically returns to neutral when released. A reel drive clutch near the end of the shaft opposite the traction drive sprocket allows reel operation independent of traction drive.



Chain - drive differential drives the traction wheels, which are dual pneumatic tired. Right-hand wheel is doweled to the right-hand differential side gear and revolves either faster or slower than the axle when necessary. Left-hand wheel is keyed to the axle shaft which is in turn keyed to the left-hand differential side gear. This wheel, therefore, always turns with the shaft. Dual shafts splined into the side gears are eliminated by this construction.



CONTEMPORARY DESIGN



Practical Design Applications for Hydrostatic Lubrication

By T. L. Corey and E. M. Kipp

Research Engineer *Chief*
Lubricants Div.
Aluminum Research Laboratories
Aluminum Co. of America
New Kensington, Pa.

Capable of solving many "impossible" bearing problems, hydrostatic lubrication is a practical design tool. Basic analysis methods are straightforward, and results impressive.

RECENT developments have focused attention on the advantages of hydrostatic lubrication for many important practical engineering applications. Hydrostatic bearings have a number of important attributes which can be extremely useful in difficult bearing situations. Among them are:

1. Ability to provide a continuous film of lubricant between bearing surfaces under conditions where it is difficult or impractical to develop and to maintain hydrodynamic lubrication. Such conditions are present, for example, during starting or stopping, at slow speeds, with reciprocating motion, or under excessive unit loads.
2. Phenomenally low coefficient of friction.
3. Greatly increased latitude in selection of suitable lubricating fluids.
4. Greater choice in the selection of suitable bearing materials.

Hydrostatic lubrication may be defined in relation to the more widely known and used principle of hydrodynamic lubrication. Hydrodynamic lubrication requires relative motion of bearing surfaces of suitable design for the formation and maintenance of the desired lubricating film; hydrostatic lubrication does not. In hydrostatic lubrication, the film of fluid lubricant between the bearing surfaces is provided by the continuous introduction of fluid under pressure to float the journal on a continuous and moving film of fluid. The manner in which the lubricating fluid is introduced under suitable pressure between the bearing surfaces is critical; it is not merely a question of piping oil under pressure into the bearing elements.

Although both liquids and gases may be used as lubricating fluids in hydrostatic designs, the great majority of theoretical and practical work to date has been with incompressible fluids such as petroleum and synthetic oils.

In this article, the basic theory of hydrostatic lubrication is reviewed, and some of the practical situations to which the concept has been usefully applied are illustrated.

Basic Hydrostatic Lubrication Theory: The theoretical basis of hydrostatic lubrication has

been covered in detail by Fuller[1], including examples of practical application. Although the theoretical derivations of the basic relationships presented by Fuller are somewhat complex, the resulting equations are straightforward and readily applied for preliminary analysis. Briefly, the following major factors are involved in designing suitable bearings in which hydrostatic lubrication is employed:

1. Geometry of the bearing surfaces.
2. Dimensions, shape and orientation of the high-pressure pad.
3. Dimensions of the bearing.
4. Optimum lubricant film thickness.
5. Effect of bearing temperatures and pressures upon viscosity of the lubricating fluid.

BEARING-SURFACE GEOMETRY: In design of journal bearings, the choice of mating-surface geometry, lies between a fitted bearing and a clearance bearing, *Fig.* 1. Generally speaking, a fitted bearing requires less volume of oil flow, and lower operating pressures for a given oil viscosity and load, than a clearance bearing operating under the same conditions. The choice will depend upon the conditions imposed on the bearing. High unit loads and low oil viscosities demand greater oil volumes at higher pressures than may be available from a practical, commercially available pump. A clearance bearing accentuates, and a fitted bearing minimizes, these difficulties. Thus, many applications may be successfully designed using a fitted bearing that would be impractical if a clearance bearing had been required.

HYDROSTATIC HIGH-PRESSURE PAD: Size and shape of the high-pressure pad will be determined by the total bearing area and the load to be lifted. Most frequently, the pad will be rectangular in shape. Optimum area of the proposed high-pres-

Bearing is a babbitt-lined, fitted bronze bearing of the partial-journal type. Maximum bearing load is 100,000 lb. For reasons associated with factors other than operation of the bearing, it was necessary to use an oil having a viscosity of 65 SSU at 100 F as the lubricant. It was also specified that both starting and operating friction be virtually eliminated. These requirements were successfully attained by supplying the hydrostatic pad with oil at a pressure of 3500 psi, and at a rate of ½-gpm. Area of the high-pressure pad is 15.6 per cent of the total projected bearing area. The pad is oriented normal to the direction of the bearing axis. Total projected bearing area is 38.5 sq in.

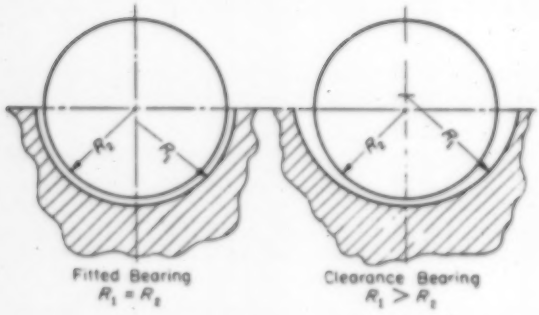
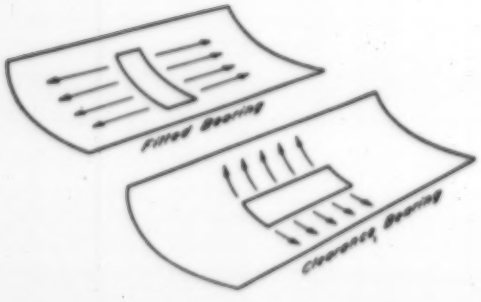
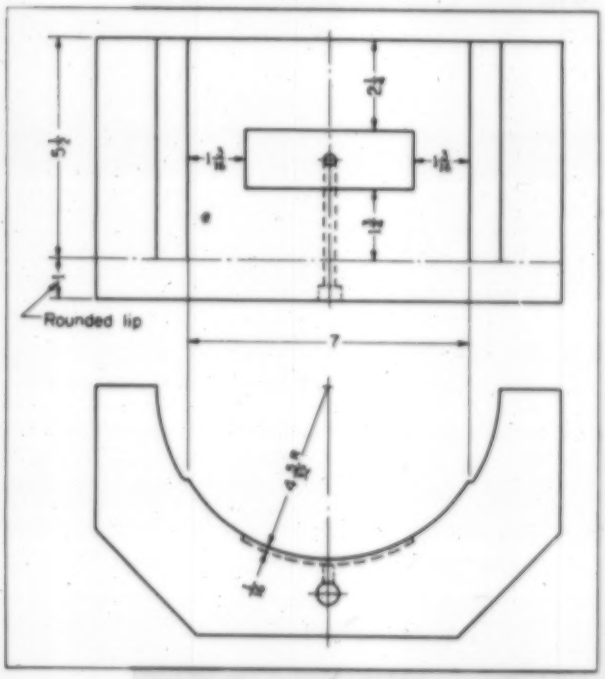


Fig. 1—Above—Basic types of hydrostatic journal bearings

Fig. 2—Below—Oil flow in hydrostatic bearing types shown in *Fig.* 1





sure pad cannot be predetermined by any single rule. In general, it is satisfactory to select a high-pressure pad area of about 2½ to 5 per cent of the normal projected area of the bearing. In any event, this is one of the variables that can be adjusted to some degree in developing a final optimum design. Load-carrying capacity of a hydrostatically lubricated fitted bearing is that of the oil pressure acting on the high-pressure pad area, added to one-half of the oil pressure acting on the remaining surface of the bearing. Evidently, final choice of pad area and oil pressure will represent the most desirable compromise between these two factors.

Pressure at which the oil is to be delivered to the high-pressure pad is independent of oil-film thickness for a fitted bearing. The situation is somewhat more complicated, however, in a clearance bearing, because lift capacity of the hydrostatic pad area depends upon a number of additional variables, such as film thickness, size, and orientation of the high-pressure pad with respect to the bearing axis.

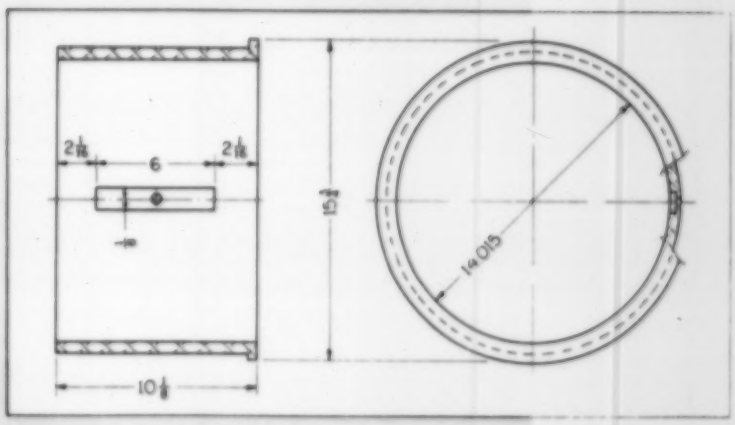
For a fitted bearing with a high-pressure pad, maximum oil leakage is along the shaft axis. For this reason, the length of the rectangular slot should be placed normal to the shaft axis, *Fig.* 2. In contrast, a clearance bearing should have its high-pressure pad placed with the length parallel to the shaft axis, because maximum oil leakage is up and through the side clearance. Thus, if the length of the pad is normal to the direction of maximum oil leakage, greater lifts with less oil flow and more even oil distribution will result.

BEARING DIMENSIONS: Bearing size usually places the second limitation on size of the high-pressure area that may be used. Remaining bearing-surface unit pressure must be carefully checked so that permissible unit pressures for the bearing material are not exceeded through removal of bearing area in providing the high-pressure pad.

OPTIMUM FILM THICKNESS: Operating film thickness has the greatest influence on both required oil pressure and flow for clearance bearings. Extremely low film thicknesses offer greatest stability and least volume of flow; however, they require greater precision in machining mating surfaces of the bearings and provide a smaller margin of safety against metal-to-metal contact. On the other hand, precision in mating surfaces of bearings may be made less critical by increasing operating film thicknesses at the expense of greater flow requirements and decreased oil-film stability. While there is no substitute for experience in selecting proper operating film thicknesses, best practice is to select the greatest film thickness consistent with available oil flow without affecting stability to the extent that the film becomes resilient enough to cause the shaft to "dance." In the other direction, film thicknesses as low as 0.0005-inch may be employed without fear of endangering life of the bearing.

EFFECT OF BEARING TEMPERATURES AND PRESSURES: For a given set of conditions, and beginning with a theoretically suitable bearing design, the success or failure of the bearing in service will depend entirely upon the viscosity of the oil supplied to it. The temperature and pressure at which the bearing is to operate determine actual viscosity of the fluid, and it is this operating viscosity that must be considered. As a qualitative approximation, the temperature rise of an oil within a bearing will be approximately 14 F for every 1000 psi

This bearing was originally designed to operate as a hydrodynamic bearing. However, it was desired to eliminate high friction present during the starting cycle. The bearing is a clearance type designed to operate at a maximum load of 160,000 lb. In this case, it was desirable to utilize, if possible, an oil of viscosity of 100 SSU at 100 F. Hydrostatic lubrication of this bearing was successfully achieved by supplying the oil to the hydrostatic pad at a rate of ¼-gpm, and at a pressure of 6500 psi. Area of the pad represents 5 per cent of the normal total projected bearing area. The pad is oriented parallel to the axis of the bearing. Total projected bearing area is 142 sq in.



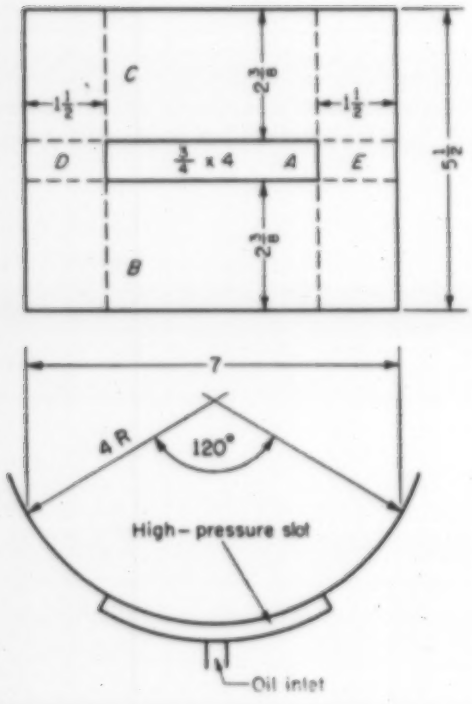


Fig. 3—Dimensions of a fitted hydrostatic bearing discussed as a practical example

pressure increment. At 5000 psi, the viscosity is approximately double that at atmospheric pressure. The importance of viscosity in hydrostatic applications cannot be overstressed.

Practical Examples: Two hypothetical problems illustrating the practical application of the basic equations are solved as representative examples.

FITTED JOURNAL BEARING: Given conditions are: bearing load, 100,000 lb; oil viscosity, 100 SSU at 100 F; operating temperature, 150 F; bearing size, 8 in. diam by 5½ in. long; journal diameter, 8 in.; load area, 120-degree arc; journal speed, 150 rpm.

Since this is a fitted bearing, maximum oil leakage will be along the shaft axis. Therefore, the high-presure slot should be oriented normal to the shaft axis.

Total projected area is 38.5 sq in. Assume ¾ by 4 in. slot, as shown in *Fig.* 3. Then, the high-pressure area equals 3 sq in., and the low-pressure area is 35.5 sq in. Thus, operating fluid pressure P for the 100,000-lb bearing load can be determined:

$$3P + 35.5\frac{P}{2} = 100{,}000$$

$$P = \frac{100{,}000}{20.8} = 4800 \text{ psi}$$

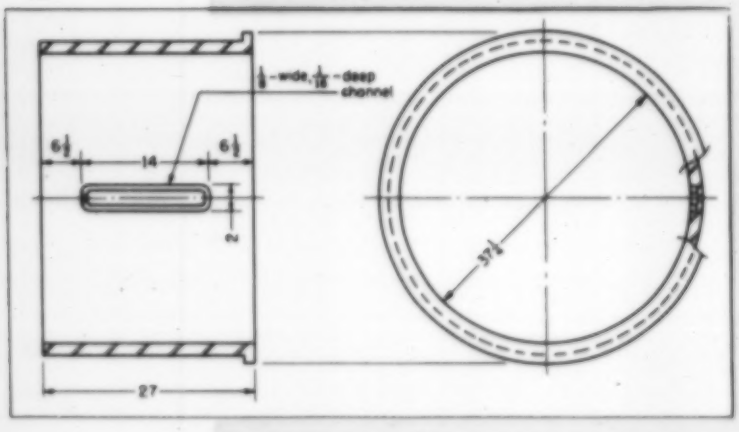
In a fitted bearing, maximum oil film thickness will be at the bottom and will gradually decrease, reaching a minimum at the 120-degree position. Flow over areas B, C, D and E (*Fig.* 3) only, will be considered. Neglecting flow over the corner areas provides a margin of safety in computing flow requirement in that the effect is that of less restricted flow.

Flow is given by the equation

$$q_l = \frac{Pbh^3}{12\mu l}$$

where b = slot width, in.; h = film thickness, in.; l = flow distance, in.; P = operating pressure, psi; q_l = flow out one side, in.^{3}/second; and μ = viscosity, reyns (lb-sec/in.^{2}). Oil viscosity for this problem equals 100 SSU at 100 F, or 24.6 × 10^{-7} reyns.

A clearance bearing originally designed to operate as a hydrodynamic bearing at normal operating speeds. At certain times, however, it was desired to operate this bearing at speeds so low that normal hydrodynamic lubrication was inadequate. This bearing supports a maximum vertical load of 1.5 million lb. Desired lubrication was attained with hydrostatic pads to which oil is supplied at a volume of 0.3-gpm and a pressure of 12,300 psi. Area of the hydrostatic pad is 2.8 per cent of the normal projected bearing area. The pad is oriented in a direction parallel to the axis of the bearing. Total projected bearing area is 1000 sq in.



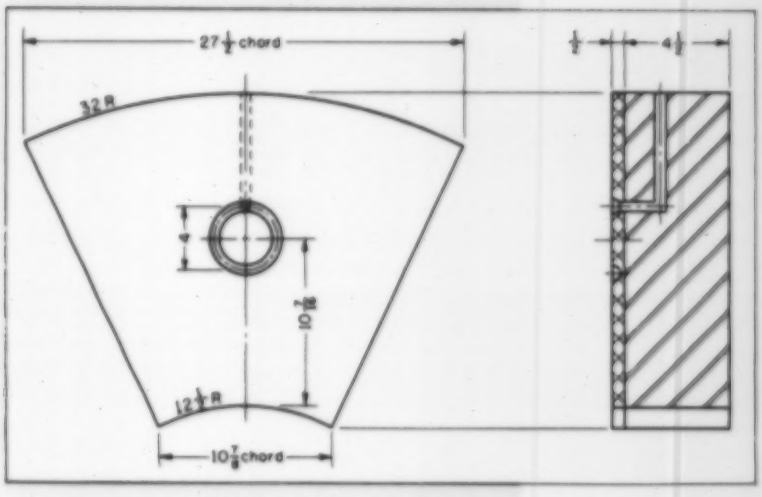
By substitution, required flow when h = 0.001-in. can be determined. Thus, axial flow out both ends of the bearing is 0.550-in.^{3}/second, and radial flow up around both sides is 0.085-in.^{3}/second. Total flow is, therefore, 0.635-in.^{3}/second or 0.165-gpm.

Actual viscosity of the fluid at the operating pressure of 4800 psi can be estimated from the facts that (1) temperature rise resulting from pressure equals 14 F per 1000 psi pressure increase; and (2) that viscosity increase resulting from pressure is[2]

$$\mu_p = \mu_o e^{BP}$$

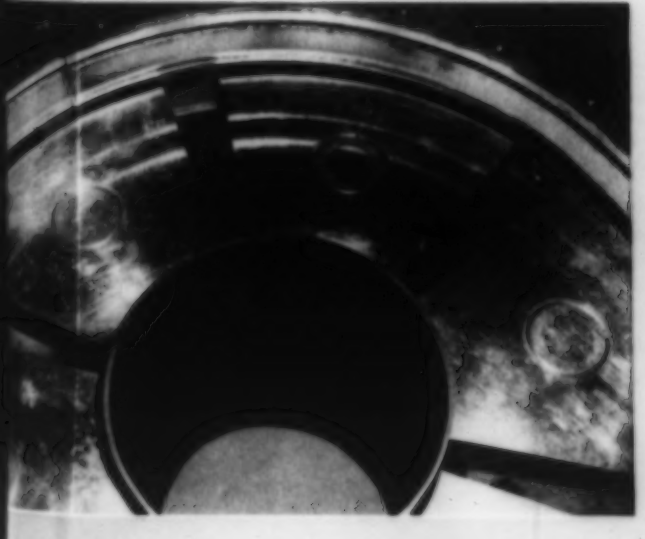
where B = constant; P = operating pressure, psi;

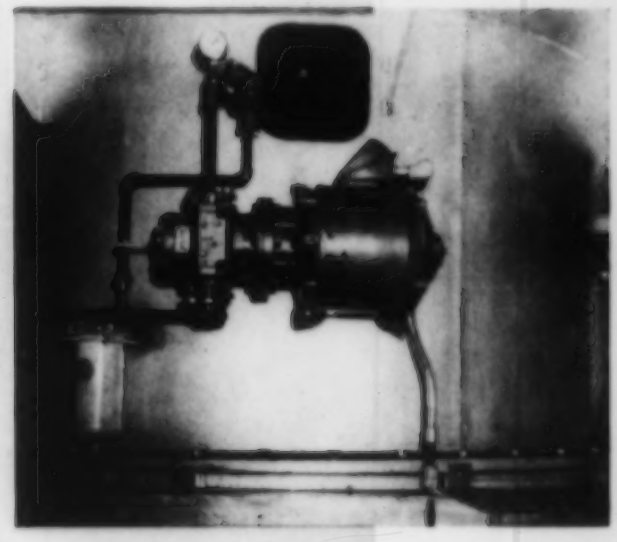
Successful application of hydrostatic lubrication to Kingsbury shoe bearings supporting a hydro-electric turbine. Elimination of excessive friction during starting and stopping operations was desired. Load supported is 500,000 lb acting on a 64-in. diam. six-shoe Kingsbury bearing. The hydrostatic pad is a circular area circumcribed by a hydrostatic groove, located in the exact center of each shoe. Oil is fed under pressure to the grooving at a rate of 0.33-gpm and pressure of 820 psi for each individual shoe. The application is completely successful in that starting and stopping torques are virtually nonexistent.



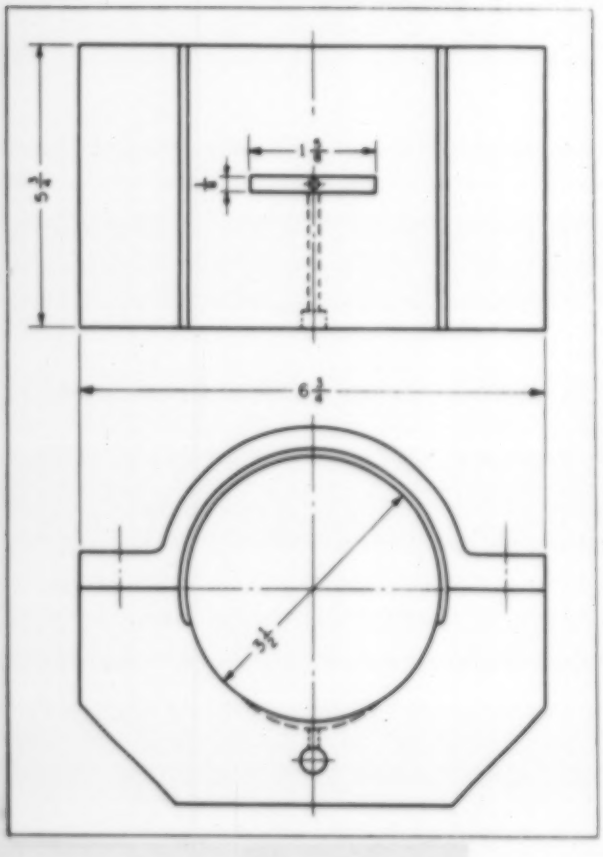
Oil for bearings is pumped through paper type filter unit to 2000-psi constant-delivery pump mounted integrally with a 3-hp motor. High-pressure oil is delivered to bearing pads through pipe at top, which connects to an oil header surrounding bearing.

Thrust bearing pads mounted in bearing tub. Oil ports can be seen at outer edge of annular grooved rings in pads.





This example is of particular interest since it involves the use of air as the hydrostatic fluid, and the bearing must operate at an ambient temperature of approximately 1200 F. The bearing is of the partial-journal sleeve type, with a maximum design load of 200 lb and an operating speed of 65 rpm. Requirements for this bearing are satisfactorily met with the use of air pumped into the hydrostatic pad area at a pressure of 35 psi and computed volume of 1.9 cfm. Actual consumption of air will be considerably less than the calculated volume since the latter was computed for room temperature. High temperature of the bearing, of course, greatly expands this volume of air, and thus provides a substantial margin of safety. In this case, the ratio of the high-pressure pad area to the total projected bearing area is 1.8 per cent, the latter being 18.7 sq in.



μ_o = viscosity at atmospheric pressure and standard temperature, reyns; and μ_p = viscosity at operating pressure, reyns.

Strictly speaking, B is not a constant, since it varies with pressure and the particular fluid. But from a practical viewpoint, values for B from *Table* 1 are sufficiently accurate for most problems.[2]

For this particular oil $B = 1.6 \times 10^{-4}$, so the equation for the bearing under consideration simplifies to

$$\mu_p = 2.16\,\mu_o$$

Temperature correction is made by going to a viscosity-temperature plot for the oil used and determining viscosity at operating temperature. Total correction for both pressure and temperature can then be expressed as[3]

$$\mu_{pt} = \mu_o\, e^{BP} \left(\frac{\mu_t}{\mu_o} \right)$$

or

$$\mu_{pt} = \mu_t\, e^{BP}$$

where μ_{pt} = viscosity at operating pressure and temperature, reyns; and μ_t = viscosity at operating temperature, reyns.

Practically speaking, μ_t can be computed by converting viscosity to reyns using a density of 0.85-0.90, since density does not vary appreciably with temperature in practical operating ranges (60-150 F).

For the particular bearing, corrections for the effects of pressure and temperature on viscosity do not have an appreciable effect upon flow and pressure requirements, and have not been noted here.

Table 1—Pressure—Viscosity Coefficients

Viscosity (SSU/100 F)	B	Viscosity (SSU/100 F)	B	Viscosity (SSU/100 F)	B
8950	2.7×10^{-4}	620	2.2×10^{-4}	85	1.35×10^{-4}
2460	2.6	310	1.9	...	...
1220	1.5	155	1.6	...	...

Summarizing, this bearing will require a high-pressure slot with dimensions as shown in *Fig.* 3, and will require a positive-displacement pump capable of delivering about 3/16-gpm. Since the initial pressure surge will be from 20 to 30 per cent greater than the calculated operating pressure, a pump of capacity of 6000 psi is indicated.

Coefficient of friction for this particular hydrostatic design can be calculated from Newton's Law of viscous friction,

$$F = \mu A \frac{dv}{dh}$$

where A = bearing area, sq in.; $(dv)/(dh)$ =

velocity gradient, in./second/in.; F = shear resisting force, lb; and μ = viscosity, reyns.

For 150 rpm, velocity is 62.83 in./sec, and

$$F = (24.6 \times 10^{-7})(35.5)\frac{62.83}{0.001} = 5.49$$

For this value of F, coefficient of friction f is

$$f = \frac{5.49}{100{,}000} = 0.0000549$$

CLEARANCE BEARING: For direct comparison with the fitted bearing, the same given conditions will be assumed. The only difference is that bearing diameter is 8.008 inches.

Oil leakage in a clearance bearing will tend to flow up around the sides. Therefore, the slot should be placed parallel to the shaft axis, *Fig.* 4. Desired operating film thickness h will be assumed to be 0.001-in. Then eccentricity C is

$$C = 1 - \frac{h}{mr} = 1 - \frac{0.001}{(0.001)(4)} = 0.75$$

where h = operating film thickness, in.; m = clearance modulus, in./in.; and r = journal radius.

Equations used to calculate required oil flow to provide hydrostatic lubrication, and pressure at which the oil must be supplied, involve two constants, A and B. Values for these constants are functions of the eccentricity, as shown in *Fig.* 5,[4] and may be read from *Fig.* 5 or *Table* 2.

Accordingly, A = 237 and B = 343. Required

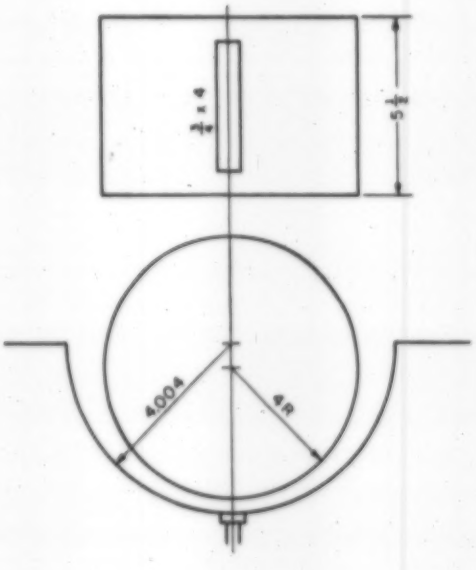


Fig. 4—Dimensions of a clearance bearing similar to the fitted bearing in *Fig.* 3

Table 2—*A* and *B* Constants for Flow and Pressure Equations

Eccentricity *C*	Constant *A*	Constant *B*
0	24.00	18.85
0.1	28.14	23.18
0.2	33.75	29.00
0.3	41.62	38.24
0.4	53.30	52.70
0.5	72.00	77.90
0.6	105.1	127.5
0.7	173.4	245.5
0.75	237.0	343.5
0.8	359.8	634.0
0.85	613.0	1 258
0.9	1 321	3 355
0.91	1 615	4 340
0.92	2 074	5 810
0.93	2 620	8 040
0.94	4 533	11 750
0.95	5 040	18 380
0.96	7 800	32 050
0.97	13 740	65 300
0.98	30 600	179 000
0.99	121 200	348 200
1.00	∞	∞

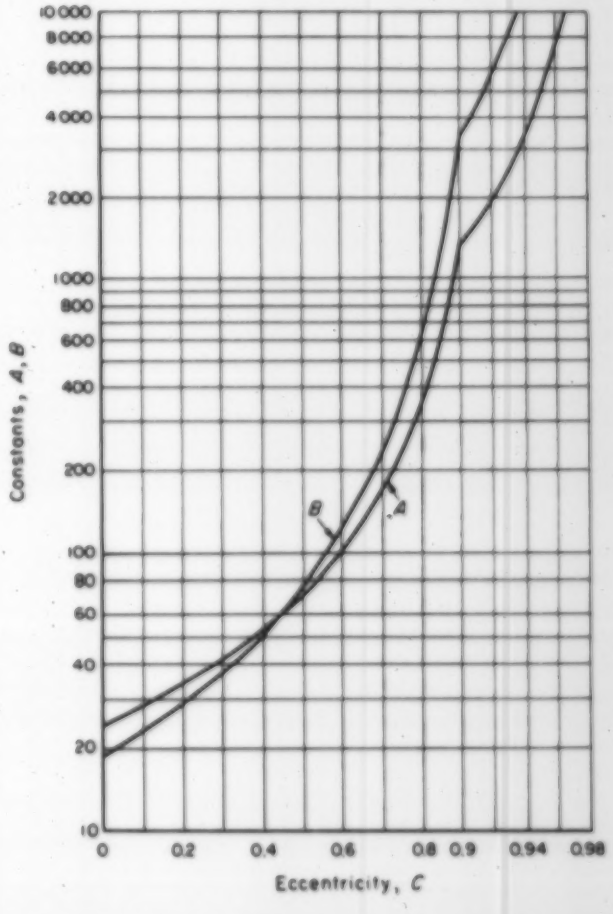


Fig. 5 — Values for *A* and *B* constants used in clearance-bearing calculations to incorporate eccentricity effects

flow with no correction for temperature and pressure is

$$q_i = \frac{Wm^3r}{\mu A}$$

where q_i = flow up one side, in.^{3}/second; and W = load, lb.

Flow up one side is, by substitution, 0.685-in.^{3}/second. Axial flow out of the ends of the bearings is disregarded; total flow is thus 1.37 in.^{3}/second or 0.356-gpm.

Table 3—Load-Carrying Capacity of Spherical Air-Film Bearings

Sphere Diam (in.)	Line Air Pressure (psi)	Seat Air Pressure (psi)	Film Thickness (in.)	Load (lb)	Flow (cfm)
2	80	70	0.005	140	1.23
4	80	70	0.004	560	1.26
6	80	70	0.003	1260	1.19

Operating pressure at this flow is given by

$$P = \frac{\mu q_i B}{bm^3 r^2}$$

with symbols as previously defined. Bearing operating pressure is thus 9050 psi.

Correction of the oil viscosity for the operating temperature and pressure will change the viscosity to about 16.8×10^{-6} reyns, and the corrected design flow to 0.52 gpm. Thus, this bearing would require a high pressure slot with dimensions as shown, and would require a positive-displacement pump capable of delivering ½-gpm at the indicated operating pressure, with the desirable added margin of 20 to 30 per cent reserve capacity.

Compressible Fluids: This article has dealt entirely with hydrostatic lubrication involving the use of incompressible fluids. The theoretical development of practical equations for compressible fluids has not progressed to the same degree as in hydrostatic lubrication using incompressible fluids. However, the use of air as a lubricant, for example, is not new,[5-8] and air has been widely applied in the lubrication of lightly-loaded, high-speed spindle bearings. It has also been used for specialty applications, such as extremely high-speed centrifuges. The load-bearing capacity of air at moderate pressure is rather surprising, as indicated by *Table* 3 for spheres of the indicated diameters.[8]

Conclusion: Useful application of hydrostatic lubrication is limited only by the ingenuity and creativeness of the design engineer. Hydrostatic lubrication is not a panacea for all bearing lubrication problems. But its potentialities should be kept firmly in mind in the design, construction and operation of bearing elements. Design requirements can now be calculated with confidence for virtually any type of mechanism involving sliding motion, and for practically any bearing geometry, size, load and speed, when using an incompressible fluid as the lubricant. When the basic simplicity and ease of application of hydrostatic lubrication becomes more widely recognized and understood, it is believed that increasing use will be made of these concepts.

BIBLIOGRAPHY

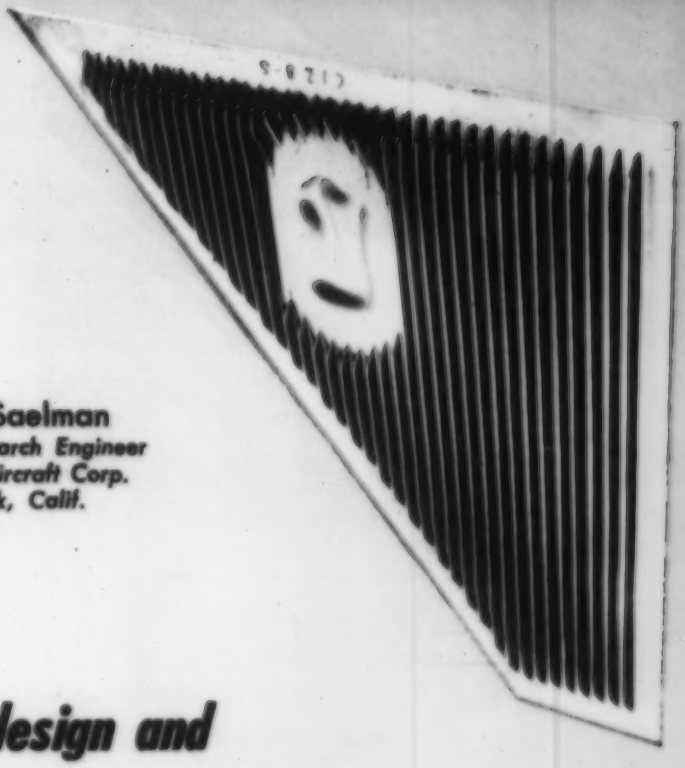
1. D. D. Fuller—"Hydrostatic Lubrication," MACHINE DESIGN, Vol. 19, June, July, August, September, 1947.
2. M. D. Hersey and R. F. Hopkins—"Viscosity of Lubricants Under High Pressures," *Mechanical Engineering*, Vol. 67, 1945, Pages 820-845.
3. M. D. Hersey and R. F. Hopkins—*Viscosity of Lubricants Under Pressure*, American Society of Mechanical Engineers, New York, 1954, Pages 64-67 and others.
4. Fuller, *loc cit*, July, Page 110.
5. J. Pigott and E. F. Macks—"Air Bearing Studies at Normal and Elevated Temperatures," *Lubrication Engineering*, Vol. 10, No. 1, February, 1954, Pages 29-33.
6. D. K. McKinley—"Air as a Bearing Lubricant," *SAE Journal*, No. 11, November, 1953, Page 108.
7. F. M. Mueller—"Air Lubricated Bearings," *Product Engineering*, August, 1951.
8. T. L. Corey, H. H. Rowand Jr., E. M. Kipp and C. M. Tyler Jr.—*Behavior of Air in the Hydrostatic Lubrication of Loaded Spherical Bearings*, Paper No. 54-Lub-8, American Society of Mechanical Engineers, New York, 1954.

They Say...

"In a very real sense, instrumentation is the nervous system of today's science and industry. In science it gives us eyes to study phenomena very remote from our ordinary senses of perception. In industry it enables us to regulate processes and to test and control the quality of our product, whether it be cigarettes or automobiles. In an atomic age where we are faced with an even greater need for precise measurements and control, instruments are indispensable tools."—ROBERT L. BUTENHOFF, *chief, Radiation Instruments Branch, Atomic Energy Commission.*

"Atomic energy and sex have much in common. Both are relevant to survival and neither should go unharnessed. By some strange social agreement, they are eschewed in polite conversation. Youngsters seem to know more about them than do their elders, and atomic energy, as sex, is surrounded by curious taboos. Both are featured, and about equally now, in the 'comics,' although atomic energy does less well in paperbacks, since it lends itself less naturally to the covers."—ROBERT R. WILSON, *director, Laboratory of Nuclear Studies, Cornell University.*

Fig. 1 — Machined integrally stiffened panels. These test structures are typical of parts that could have been press forged



By B. Saelman
Weight Research Engineer
Lockheed Aircraft Corp.
Burbank, Calif.

Basic design and producibility considerations for

INTEGRALLY STIFFENED STRUCTURES

Fig. 2—Above—Thin-skin panel section produced by press forging. Skin thicknesses as low as 0.1-inch with a stiffener height of one inch have been obtained

Fig. 3—Typical extruded integrally stiffened panels showing flat flanged stiffener designs

PRESENT trends toward higher performance levels in machines and equipment continue to place more exacting demands on the design of structural components. In aircraft, where weight is always a critical problem, integrally stiffened structural sections, *Figs.* 1 to 4, have proved particularly effective as a lightweight, high-strength construction. Composed of skin and stiffeners formed from the same unit of raw stock, these one-piece panel sections can be produced by several different techniques. Size and load requirements are usually the important considerations in selecting the most feasible process.

The two test panels in *Fig.* 1 were machined to shape but, for best results, could have been press forged as was the test panel in *Fig.* 2. A machining set-up for a long panel is illustrated in *Fig.* 5.

Typical extruded panel sections are shown in *Fig.* 3, rolled sections in *Fig.* 4; a variety of stiffener constructions is possible. Casting has also

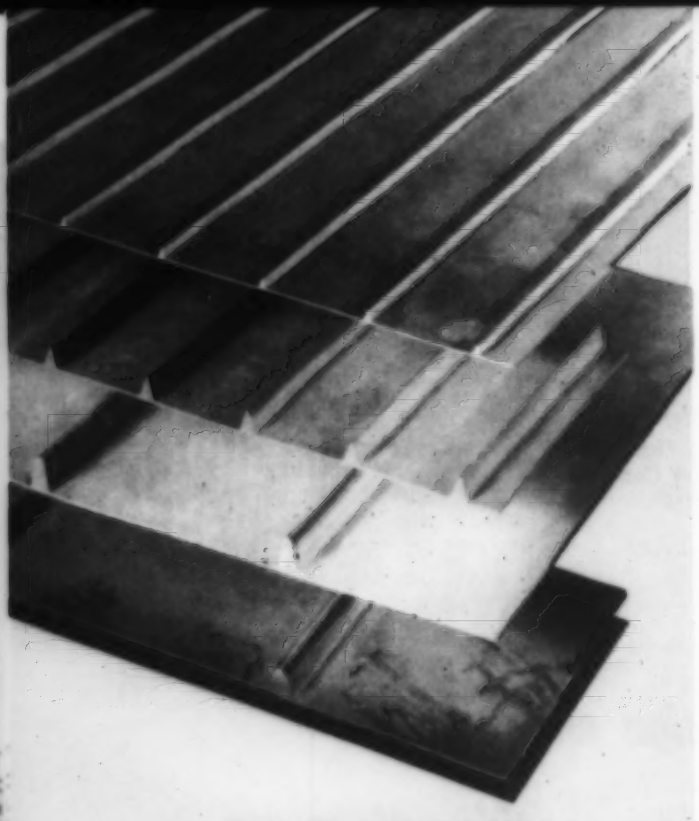


Fig. 4—Typical rolled panel sections showing different integral stiffener constructions possible

long been successfully employed in the production of such structural sections.

For highly loaded long panels, extrusions or machined plates are most commonly employed. Since extrusion width capacities are somewhat limited, attachment of a series of extruded panels with spanwise slices may be required in some applications. Splicing can often be eliminated or reduced with billet or plate stock of sufficient width to permit machining an integral structure or, at least, to provide a structure with fewer lineal sections. Section discontinuities such as encountered in the region of cutouts can often be produced more easily from machined plate.

From a cost standpoint it is usually better to extrude integrally stiffened structures than to machine a section of the same size from a billet or plate. However, the minimum extrusion thickness is about 0.09-inch and frequently, where loads are light, considerable additional machining is needed to produce an efficient design. In some of these cases, machining from a billet seems to be more economical. Furthermore, under light loads a machined section with a flat- stiffener element may be sufficient.

Actually, limitations on minimum thickness for both machined plates and extrusions may preclude the efficient use of these methods for lightly loaded panels. Where thin section applications are encountered, rolled and forged integrally stiffened structures may be more suitable.

Design Advantages: From a structural standpoint, appreciable weight savings are possible through the integral-section design which also develops high resistance to buckling loads. In addition, the reduction in the number of basic assembly attachments gives a smooth exterior skin surface. Another potential advantage of the integrally stiffened structure is the elimination of attachment flanges with a corresponding redistribution of this material for optimum stiffener proportions. However, some production development work is necessary to exploit this advantage fully.

In aircraft applications, the most significant advantages of integrally stiffened structures over comparable riveted panels have been:

1. Reduction of amount of sealing material for pressurized shell structures.
2. Increase in allowable stiffener compression loads by elimination of attachment flanges.
3. Increased joint efficiencies under tension loads through the use of integral doublers, etc.
4. Improved performance through smoother exterior surfaces by reduction in number of attachments and nonbuckling characteristics of skin.

Integral fuel tanks and pressurized shells usually create sealing problems for a riveted structure. *Fig. 6a*. These problems are eliminated to a large extent by integral stiffeners. Also, as exemplified by certain airplane wing constructions, puncturing

Fig. 5—Machined integrally stiffened panel mounted for cutting operation. Work is vacuum held on cutter bed table; cams control motion of cutting head

of the skin surface for structural attachments is avoided by attaching internal elements to integral stringers with clips, *Fig.* 6*b*.

In riveted panel constructions, beam caps are sometimes heavier than necessary because of provisions for skin splicing, additional flange width for attachments, proximity to contour, edge distance requirements, etc. The resulting thin, wide cap elements, *Fig.* 7*a*, reduce the average allowable compressive stress of the beam caps with a resultant loss in efficiency. An integral cap design, *Fig.* 7*b*, provides a more efficient distribution of material and thus permits a greater distance between cap centroids. Integrally stiffened panels also have an advantage for tension applications because integral doubler pads may be incorporated at joints, *Fig.* 8, permitting higher net section efficiencies.

Integrally stiffened structures have their greatest advantage in highly loaded applications because of their minimum section size. Investigations have indicated that a combination integrally stiffened and riveted compression section such as shown in *Fig.* 9 can attain an exceptionally high degree of structural efficiency. In one case, an allowable stress of 65,000 psi was attained on both net and gross skin area with no skin buckling. For example, on the tension surface of the Lockheed *Constellation* inner wing, a weight reduction of approximately 15 per cent was realized by the use of an integrally stiffened structure. Allowable stress for wing compression surfaces has risen approximately 20 per cent in the past 10 years.

Integral Structure Design: In the design of integrally stiffened structures, compromises must be made between ideal and practical strength and shape requirements as balanced against final cost, and, sometimes, production time. The optimum integral structure cross-section shape, from the standpoint of resistance to overall panel buckling, is one which has a maximum moment of inertia for a given panel weight. The thickness h of a machined or extruded integral panel is usually a function of the length and width of the original stock employed. Thus, maximum stiffener depth is usually determined by stock thickness and, in some cases, clearances.

The effective thickness of an integrally stiffened panel having a cross-sectional shape as shown in *Fig.* 10 is given by

$$t_e = t_s + \frac{t_w\,(h - t_s)}{p} \qquad (1)$$

where terms are defined in the NOMENCLATURE. The moment of inertia of this integral panel cross-section is:

$$I_o = \frac{h^3\,t_w}{3\,b} - \frac{h^4\,t_w^2}{4\,b^2\,t_e} \qquad (2)$$

If t_e, h and p are held constant, a maximum value for I_o, and ρ, is found if the derivative of I_o with respect to t_w in Equation 2 is set equal to zero. Solution of the resulting equation for stiffener

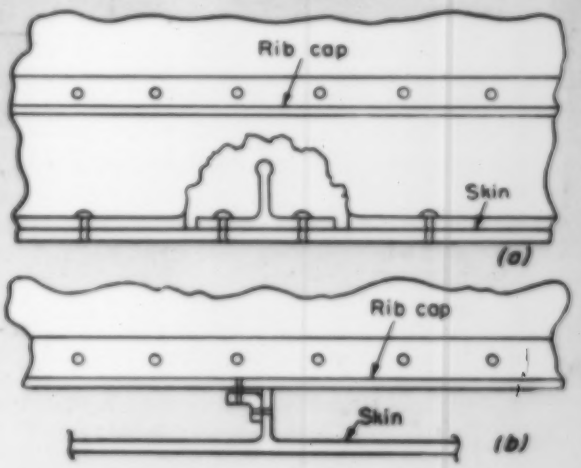


Fig. 6—Stiffened skin constructions for aircraft wing assemblies showing, *a*, riveted skin and stiffener combination and, *b*, integrally stiffened design

Fig. 7—Typical beam cap constructions for, *a*, riveted design and, *b*, integral design

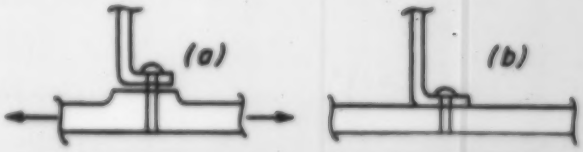


Fig. 8—Two panel joint designs showing at *a* the use of integral doubler pads which permit higher net section efficiencies as compared to the conventional joint design at *b*

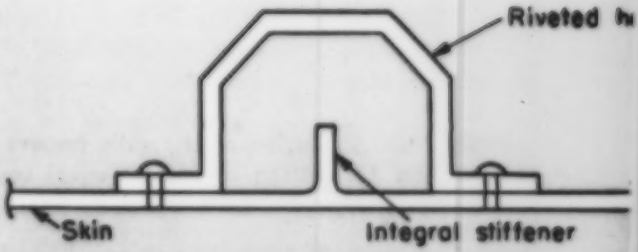


Fig. 9—Combination integrally stiffened and riveted panel construction for use under high compression loads

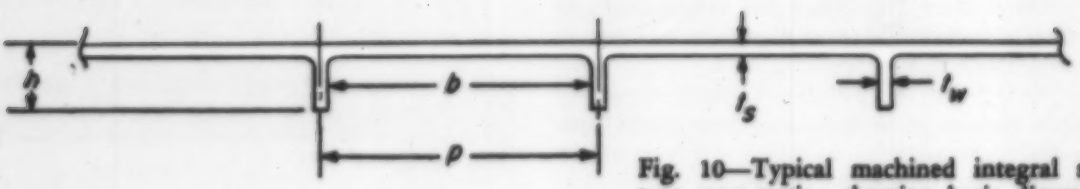


Fig. 10—Typical machined integral structure cross-section showing basic dimensions

thickness gives

$$t_w = \frac{2\,b\,t_s}{3\,h} \quad \ldots\ldots (3)$$

If quantities of higher order are neglected, the expression for t_s can also be written as:

$$t_s = t_s + \frac{h\,t_w}{b} \quad \ldots\ldots (4)$$

Substituting the value of t_s from Equation 4 into Equation 3 gives

$$t_s = \frac{h\,t_w}{2\,b} \quad \ldots\ldots (5)$$

Then, if value of t_w from Equation 3 is substituted in Equation 5,

$$t_s = \frac{t_s}{3} \quad \ldots\ldots (6)$$

When axial loads on the integrally stiffened panel are variable, it is often desirable to taper the panel in accordance with load variation. To achieve minimum weight in a tapered panel design, it is best to have a maximum amount of material in the stiffener but still retain unbuckled skin.

Buckling stress of the skin panel can be determined from

$$\sigma_s = KE\left(\frac{t_s}{b}\right)^2 \quad \ldots\ldots (7)$$

From Equation 1,

$$t_s = \frac{p\,t_s - h\,t_w}{p - t_w} \quad \ldots\ldots (8)$$

Combining Equations 7 and 8,

$$\sqrt{\frac{\sigma_s}{KE}} = \frac{t_s}{b} = \frac{p\,t_s - h\,t_w}{b\,(p - t_w)} \approx \frac{t_s}{b} - \frac{A_w}{b^2} \quad (9)$$

or

$$A_w = b\,t_s - b^2\sqrt{\frac{\sigma_s}{KE}} \quad \ldots\ldots (10)$$

Taking the derivative of A_w with respect to b in Equation 10, setting the result equal to zero, and solving gives,

$$t_s = \frac{t_s}{2} \quad \ldots\ldots (11)$$

For optimum design of integrally stiffened structures, all allowable stresses corresponding to the various modes of compression failure should be equal and of the same magnitude as the applied stress. Thus,

$$P_a = \sigma_c\,t_s = K_1\,t_s\,\rho^2 \quad \ldots\ldots (12)$$

Then, from Equation 2,

$$\rho^2 = \frac{I_s}{t_s} = \frac{h^3\,t_w}{3\,b\,t_s} - \frac{h^4\,t_w^2}{4\,b^2\,t_s^2} \quad \ldots\ldots (13)$$

Nomenclature

- A = Panel cross-section area, square inches
- A_f = Area of stiffener flange, square inches
- A_w = Stiffener area, square inches
- b = Effective width (unbuckled) of skin, inches
- b_e = End fixity coefficient
- C = Width of skin panel, inches
- E = Young's modulus of elasticity, psi
- E_t = Tangent modulus of elasticity, psi
- h = Stiffener depth plus ½ skin thickness, inches
- h_w = Stiffener depth plus skin thickness, inches
- I_f = Moment of inertia about section neutral axis, inches^4 per inch of width
- I_s = Moment of inertia of horizontal stiffener flange about axis y-y (*Fig.* 15), inches^4
- K = Buckling constant
- $K_1 = C\,\pi^2\,E/l^2$ = Elasticity constant
- L' = Effective column length, inches
- l = Actual column length, inches
- P = Applied load, pounds per inch
- P_a = Single panel load, pounds
- p = Pitch distance between stiffeners, inches
- R = Total effective spring constant of skin and stiffener, pounds per inch
- R_s = Spring constant of skin, pounds per inch
- R_w = Spring constant of stiffener, pounds per inch
- s_n = Allowable stress on net section (unbuckled portion of gross area), psi
- s_s = Allowable buckling stress of skin, psi
- s_w = Allowable stiffener stress, psi
- t_s = Effective panel thickness, inches
- t_f = Thickness of stiffener flange, inches
- t_s = Skin or flat sheet thickness, inches
- t_w = Stiffener thickness, inches
- w_f = Width of stiffener flange, inches
- $a = t_w/b$ = stiffness ratio
- ν = Poisson's ratio
- ρ = Radius of gyration of panel cross-section, inches
- ρ_f = Radius of gyration of horizontal stiffener flange, inches
- σ_c = Buckling stress of skin panel, psi
- σ_f = Euler column stress, psi
- σ_s = Buckling stress of stiffener flange, psi

Combining Equations 12 and 13 gives

$$P_a = K_1\left(\frac{h^3 t_w}{3b} - \frac{h^4 t_w^2}{4 b^2 t_s}\right) \quad \ldots\ldots (14)$$

From this equation, effective panel thickness may be expressed as:

$$t_s = \frac{K_1 h^4 a^2}{4}\left(\frac{1}{\frac{K_1 h^3 a}{3} - P_a}\right) \quad \ldots\ldots (15)$$

where the stiffness ratio $a = t_w/b$. Differentiating Equation 15 with respect to a, setting the result equal to zero, and solving for a gives

$$a = \frac{6 P_a}{K_1 h^3} \quad \ldots\ldots (16)$$

From Equation 15 and 16,

$$t_s = \frac{9 P_a}{h^2 K_1} \quad \ldots\ldots (17)$$

Thus if P_a, K_1 and h are held constant, a and t_s can be evaluated with Equations 16 and 17.

If no initial buckling in the skin panel is to be permitted, then

$$\frac{b}{t_s} = \sqrt{\frac{KE}{\sigma_s}} \quad \ldots\ldots (18)$$

From Equation 12,

$$\sigma_c = K_1 \rho^2 \quad \ldots\ldots (19)$$

However, $\sigma_c = \sigma_s$ or, from Equations 18 and 19,

$$K_1 \rho^2 = KE\left(\frac{t_s}{b}\right)^2 \quad \ldots\ldots (20)$$

Thus, skin panel width is:

$$b = \frac{t_s}{\rho}\sqrt{\frac{KE}{K_1}} \quad \ldots\ldots (21)$$

Then, from Equations 4, 16 and 17,

$$t_c = t_s + \frac{6 P_a}{K_1 h^2} = t_s + \frac{2 t_s}{3} \quad \ldots\ldots (22)$$

It can be seen that the skin thickness t_s equals $t_c/3$, as given previously by Equation 6.

To prevent buckling when $t_s = t_c/3$, the skin panel width should be:

$$b = \frac{t_s}{3}\sqrt{\frac{KE}{\sigma_s}} \quad \ldots\ldots (23)$$

However, when $t_s = t_c/2$,

$$b = \frac{t_s}{2}\sqrt{\frac{KE}{\sigma_s}} \quad \ldots\ldots (24)$$

Thus, when only the applied load N and stiffener height h are given, the effective thickness, t_c can be determined from Equation 17 and a from Equation 16. If, in addition, it is required that the skin remain unbuckled, t_s can be determined from Equation 6 and b in turn can be calculated from Equation 23. Finally, t_w can be evaluated from

$$t_w = ba \quad \ldots\ldots (25)$$

where the value of a is given by Equation 16.

The assumption has been made that the buckling constant, K, of the skin is known. Actually, the constant K, which can be determined from the chart in *Fig.* 11, depends on the dimensions of the stiffeners and involves a rather complex mathematical relationship.

When flanged stiffeners are employed, *Fig.* 12,

Fig. 11—Chart for determining the buckling coefficient K of integrally stiffened skins for three values of t_s/t_w

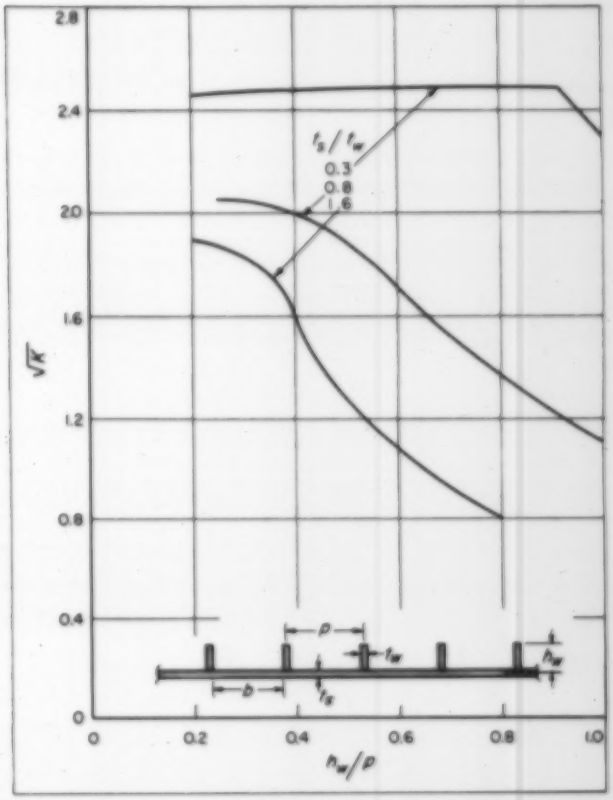
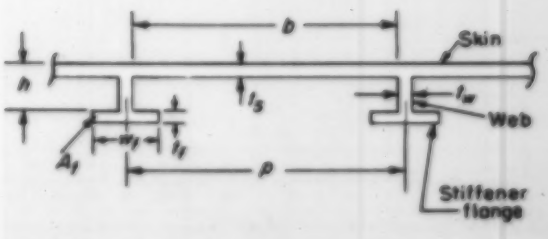


Fig. 12 — Typical flanged integrally stiffened structure with basic dimensions



$$t_s = t_e + \frac{t_w(h - t_e)}{p} + \frac{A_f}{p} \qquad (26)$$

The moment of inertia for this type of cross section is

$$I_o = \frac{A_f h^2 + \frac{t_w h^3}{3}}{p} - \frac{\left(\frac{t_w h^2}{2} + A_f h\right)^2}{p^2 t_s} \qquad (27)$$

If it is assumed that t_s, h, t_w and p are held constant and A_f and t_s are variable, it can be shown that A_f gives a maximum I_o value for the section when

$$A_f = \frac{p t_s - h t_w}{2} = p t_s \qquad (28)$$

If it is assumed that t_s, A_f, p and h are held constant and t_w and t_s are variable, the derivative of equation 27 with respect to t_w, when set equal to zero and solved for t_w, gives

$$t_w = \frac{2}{h}\left(\frac{p t_s}{3} - A_f\right) \qquad (29)$$

When $A_f = 0$, Equation 29 reduces to Equation 3.

The integral structure is often designed so that the skin panel is unbuckled at ultimate loads. For a compression panel, it can be shown that optimum design provides either a nonbuckled skin or a skin that is completely buckled with maximum material in the stiffener. However, most airplane structures carry shear loads in addition to axial load and from this standpoint unbuckled skin is preferable.

Effective thickness, t_e, per unit of width for an integrally stiffened panel cross section is a minimum for an infinitely thin web and also for a nonbuckling web. This minimum value is reached when

$$t_e = \frac{P_a}{s_a} \qquad (30)$$

If the skin is to be nonbuckling, it is desirable that

$$\frac{t_s}{b} \geq \sqrt{\frac{\sigma_c}{KE}} \qquad (31)$$

Under this condition, the balance of a given amount of panel material can be placed in the stiffener, permitting an increase in s_a.

Sometimes, such factors as torsional stiffness, etc., dictate a specific value of t_s. The minimum ratio for nonbuckled skin is

$$\frac{t_s}{b} = \sqrt{\frac{\sigma_s}{KE}} \qquad (32)$$

For highly loaded structures, the compression allowable may be equal to the ultimate strength of the material which is often equal to the compression yield stress. If this can be accomplished by a pure monocoque design (all material in a thick plate), the design would be optimum. In a wing box structure, for example, the pure monocoque becomes most efficient because the material is used at a maximum distance from the neutral and torsional axis.

Fig. 13—Chart for determining initial buckling stress of stiffened skin panels by using b, K, and t_s from Fig. 11

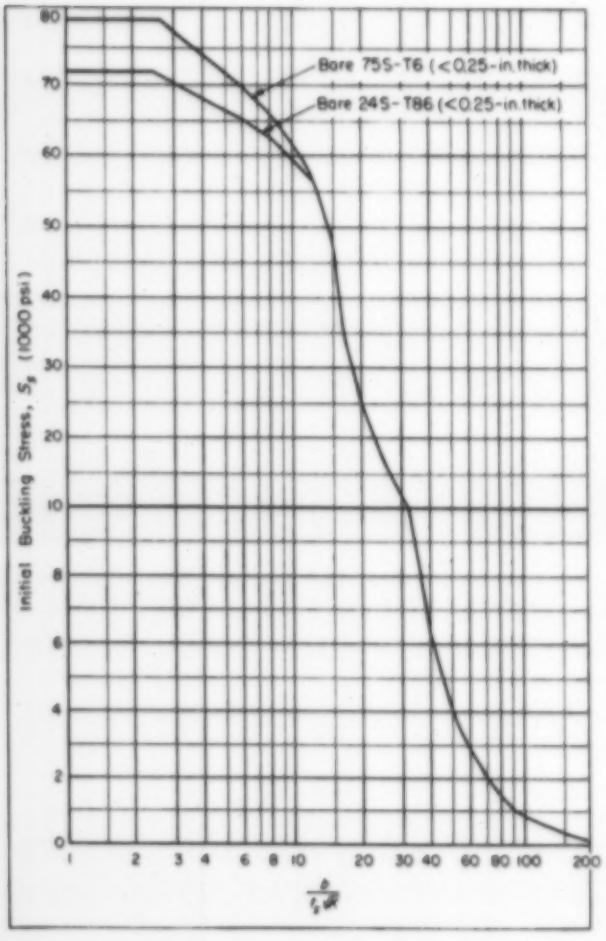
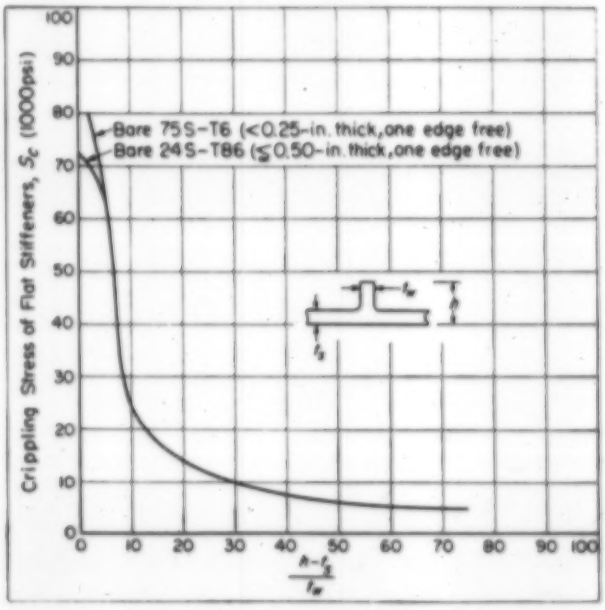


Fig. 14—Chart for evaluating crippling stress of integral flat stiffeners made of the same materials as the panels of Fig. 13


Bare 75S-T6 (<0.25-in. thick, one edge free)
Bare 24S-T86 (≤0.50-in. thick, one edge free)
Crippling Stress of Flat Stiffeners, S_c (1000 psi)
$\frac{h-t_s}{t_w}$

In lightly loaded structures, the minimum skin thickness selected is determined by producibility and stiffeners are then positioned for maximum spacing.

Panel Failure Consideration: The following possible modes of failure should be considered for the integrally stiffened panel of *Fig.* 10:

1. Overall column failure.
2. Individual skin panel failure by initial compression buckling.
3. Stiffener crippling (one edge fixed and one edge free).

To study overall column failure, a column stress curve must be constructed on the basis of section pitch p. This construction can be accomplished by a number of approaches. For example, if a plot of tangent modulus of elasticity versus column stress is available for a particular material, the following relationships can be used:

$$\sigma_c = \frac{P}{A} = \frac{\pi^2 E_t}{\left(\frac{L'}{\rho}\right)^2} \quad (33)$$

or

$$\frac{L'}{\rho} = \pi \sqrt{\frac{E_t}{\sigma_c}} \quad (34)$$

For various values of column stress σ_c, the corresponding values of tangent modulus E_t can be obtained from the tangent modulus curve. The ratio L'/ρ can then be evaluated from Equation 34. From these data, a plot of σ_c versus L'/ρ can be made. The radius of gyration, ρ, can be calculated from Equation 13.

For example, in a wing or fuselage panel, the column length L' can be taken as the rib or ring spacing, respectively. If the L' and ρ values are known, the allowable column stress, σ_c can be determined. Allowable load, $P_a = p\, t_s\, \sigma_c$, can then be compared with the applied load.

To prevent skin panel failure by initial compression buckling, the charts in *Figs.* 11 and 13 are useful in design. Although *Fig.* 13 only provides data for two types of aluminum alloy flat sheets, curves for other materials can also be readily drawn. The buckling constant K for three values of t_s/t_w can be obtained from *Fig.* 11. This constant is a measure of the amount of edge restraint given the panel by the stiffeners.

The initial buckling stress for a flat sheet is

$$s_s = K E_t \left(\frac{t_s}{b}\right)^2 \quad (35)$$

Applied stress must not exceed this value.

Crippling stress for a stiffener with one edge fixed and one edge free can be obtained from a chart such as shown in *Fig.* 14 for two types of aluminum alloys. Usually the crippling stress is lower than the initial buckling stress of the flange and thus is the critical value.

Cozzone and Melcon[1] show methods of determining all of the preceding modes of compression failure when the stress-strain curve of the material is given. A design is considered efficient when the applied stress is approximately equal to each of the three allowable stresses. For the section shown in *Fig.* 10, design should be based on the first two conditions of failure listed previously: (1) Overall column failure and (2) individual panel failure.

Sidewise Stability: The criteria for sidewise stability of the stiffener flanges in the panel design shown in *Fig.* 12 are:

$$\sigma_f = 2\sqrt{\frac{E \rho_f^2 R}{A_f}} \quad (36)$$

when

$$L' \geq \pi \left(\frac{E I_f}{R}\right)^{1/4} \quad (37)$$

and

$$\sigma_f = \pi^2 E \left(\frac{\rho_f}{L'}\right)^2 + \frac{R(L')^2}{\pi^2 A_f} \quad (38)$$

when

$$L' < \pi \left(\frac{E I_f}{R}\right)^{1/4} \quad (39)$$

where the total effective spring constant, R, of the skin plus the stiffener is given by

$$\frac{1}{R} = \frac{1}{R_w} + \frac{1}{R_s} \quad (40)$$

The spring constant of the stiffener can be determined from

$$R_w = \frac{E t_w^3}{4 h^3 (1 - \nu^2)} \quad (41)$$

The spring constant of the skin from

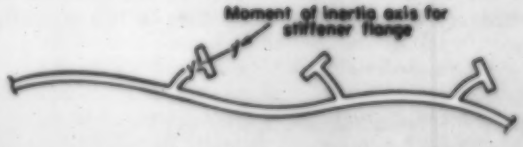
$$R_s = \frac{E t_s^3}{3 b h^2 (1 - \nu^2)} \quad (42)$$

To insure that the web and skin combination, *Fig.* 15, will not destabilize the stiffener flange at a premature stress, Sandorff[2] gives the auxiliary condition:

$$\frac{E t_f w_f^3}{R p^4} > 12 \quad (43)$$

The foregoing methods of analysis, although not the most exact that could be developed, will provide results of sufficient accuracy within the range of normal design requirements.

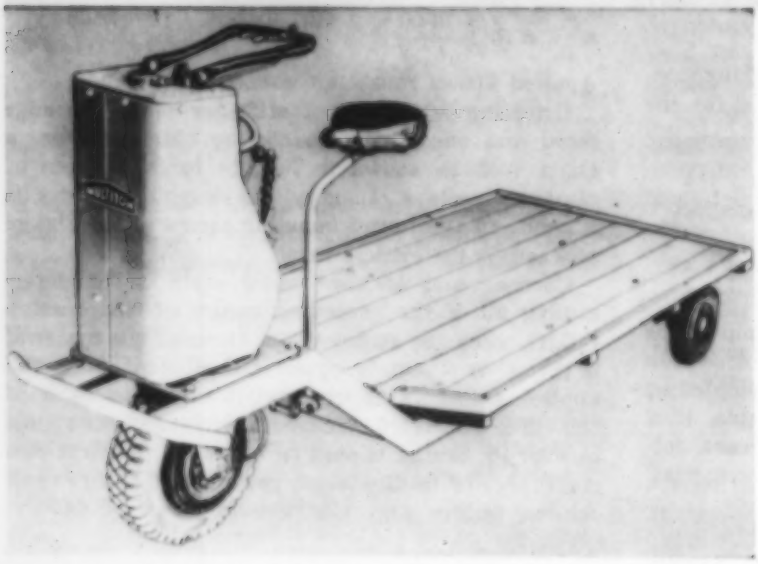
Fig. 15—Integrally stiffened structure showing flanged stiffeners in exaggerated unstable condition



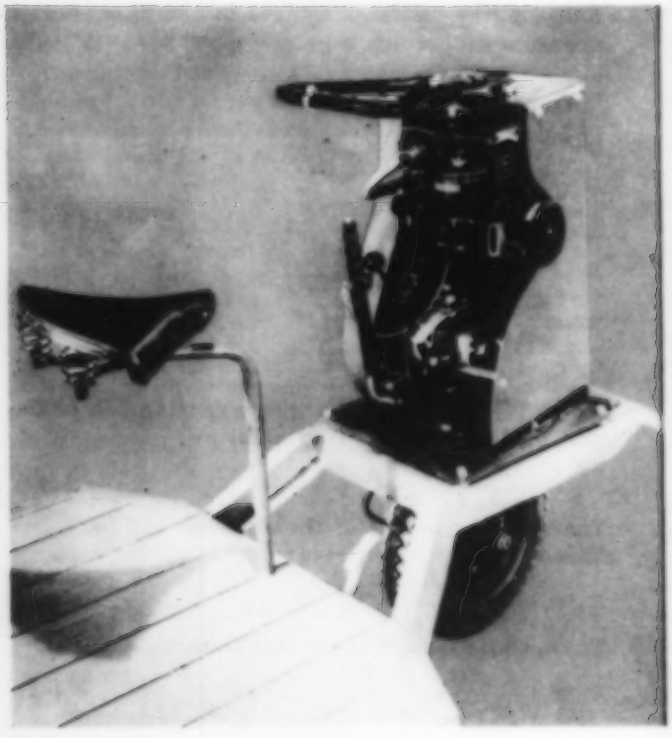
References

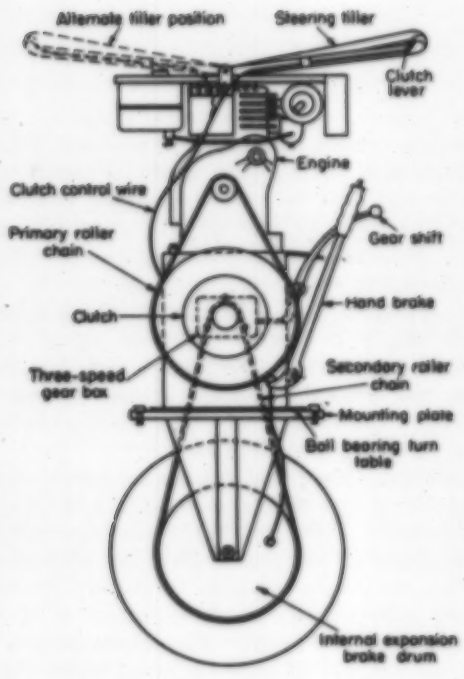
1. F. P. Cozzone and M. A. Melcon—"Nondimensional Buckling Curves—Their Development and Application," *Journal of the Aeronautical Sciences*, Vol. 13, No. 10, October, 1946. Pages 511-517.
2. P. E. Sandorff—"Bending Rigidity and Column Strength of Thin Sections," *Transactions of the American Society of Mechanical Engineers*, Vol. 69, No. 8, November, 1947. Pages 833-841.

"Outboard" Motor Powers Industrial Truck



APPLICATION of the outboard motor concept to an industrial platform truck has resulted in a lightweight vehicle capable of carrying approximately four times its own weight and priced at about $500.00. Capacity is 1500 pounds and total weight of the unloaded truck is 370 pounds. Platform measures 69 inches long and is 38 inches wide. Known as the Multiton-Excelsior, the truck is manufactured by Stokvis-Edera & Co. Inc. Maximum speed is 8 mph. When fully loaded, the truck can climb a 20-degree incline.





Power unit, which includes Briggs & Stratton one-cylinder air-cooled engine, clutch, three-speed transmission, drive wheel and brake is attached to the truck by four bolts. Reversing is accomplished by simply swiveling the entire unit 180 degrees on its ballbearing turntable, which allows full 360-degree rotation. This feature reduces cost by eliminating the need for a reverse gear in the transmission and additionally makes the transmission's three speeds available for both forward and reverse operation. Normally, the operator is seated, but he can also control the truck while standing or walking, since the steering tiller can be swung forward or backward over the engine. In addition to the hand-operated drive-wheel brake, there are brakes on the two rear wheels which are foot-pedal actuated. Cork inserts serve as friction facings in the clutch. These inserts may be replaced in approximately ten minutes, according to the manufacturer.

Unit Weights of Metals

A tabulation for more than 240 types of ferrous and nonferrous metals

By George Sorkin and Willard H. Hawley Jr.

Metallurgists
Bureau of Ships
Dept. of the Navy
Washington, D. C.

WEIGHT considerations are encountered in practically every area of design engineering.

Machines such as ships and aircraft are designed so that weight and particularly weight distribution are of prime importance. Complete weight estimates of hull and machinery in a ship, including vertical and longitudinal centers of gravity and moments, are prepared.

In the design of rotating machinery, unit weights are of prime importance. For example, minimum interference fit of flywheel bores depends on the density of the particular alloy used.

Weights of castings must often be determined. When parts or patterns are not available for weighing, or the pattern is not of solid construction, the design must be broken into simple sections, and the weight of each section calculated. This is done, of course, by determining the volume of a part in cubic inches and multiplying this value by the weight per cubic inch of the material.

Successful prediction of weights requires accurate unit weights of metals. In general, unit weights are based on averages of many tests covering all combinations of compositional limits. Some specifications for alloys such as those for "commercial brass" permit a substantial density range. In these cases a range is actually shown in the table in this data sheet.

Experimentally determined densities are frequently less than values calculated from alloy composition and densities of the component elements. Densities have definite relationships to the specific material form involved (casting, wrought form, etc.), and the following table reflects this consideration.

In general, designations for aluminum are those of the Aluminum Association, designations for magnesium are ASTM, and designations for steel are AISI or SAE.

ACKNOWLEDGMENT

These data have been compiled from a vast amount of information published on the subject. The authors wish to acknowledge with sincere appreciation the help obtained in the preparation of this list from personnel and publications of the following organizations: Air Force; Allegheny-Ludlum Steel Corp.; Aluminum Co. of America; A. M. Byers Co.; American Brass Co.; American Iron and Steel Institute; American Society for Metals; Ampco Metal Inc.; Army, Office of Chief of Engineers; Atomic Energy Commission; Bethlehem Steel Co.; Beryllium Corp.; Brass and Bronze Ingot Institute; Copper and Brass Research Association; Dow Chemical Co.; International Nickel Co.; Kaiser Aluminum and Chemical Corp.; Malleable Founders' Society; Navy, Bureau of Aeronautics; Navy, Bureau of Ships; New Jersey Zinc Sales Co.; Rem-Cru Titanium Inc.; Reynolds Metals Co. Inc.; Scovill Mfg. Co.; Tin Research Institute Inc.; Westinghouse Electric Corp.

Iron and Steel

Metal	Weight (lb/in.³)	Weight (lb/ft³)
Iron, gray, castings	0.261	451
Iron, malleable, castings	0.262	453
Iron, nodular, castings	0.260	449
Iron, pig	0.260	449
Iron, wrought	0.278	480
Steel, carbon and low alloy	0.283	489
Steel, stainless		
301 (16-6 Cr-Ni)	0.290	501
302 (17-8 Cr-Ni)	0.286	494
303 (17-9 Cr-Ni)	0.286	494
304 (18-8 Cr-Ni)	0.286	494
305 (19-10 Cr-Ni)	0.284	491
309 (23-12 Cr-Ni)	0.285	492
310 (25-20 Cr-Ni)	0.286	494
316 (16-10 Cr-Ni)	0.286	494
317 (17-11 Cr-Ni)	0.286	494
321 (17-8 Cr-Ni)	0.286	494
323 (16-6 Cr-Ni)	0.290	501
347 (17-9 Cr-Ni)	0.285	492
403 (12 Cr)	0.280	484
410 (13 Cr)	0.281	486
416 (13 Cr)	0.280	484
420 (13 Cr)	0.281	486
430 (17 Cr)	0.275	475
431 (16-2 Cr-Ni)	0.281	486
(8-18 Cr-Ni)	0.285	492
325 (7-20 Cr-Ni)	0.285	492
(17-6 Cr-Ni)	0.286	494
Mod. 410 (13-1 Cr-Ni)	0.280	484
(12 Cr-Mo)	0.281	486
(19-10 Cr-Ni) nonmagnetic	0.284	491
(19-11 Cr-Ni) nonmagnetic	0.284	491
(19-12 Cr-Ni) nonmagnetic	0.284	491
Nonmagnetic Cr-Ni-Mn		
17-4-6	0.287	495
16-6-1	0.287	495
Steel, alloy		
2300 & 2500 series	0.283	489
3100 & 3300 series	0.283	489
4300, 4600, & 4800 series	0.284	491
(3¼-¼ Si-Cr)	0.277	479
(5-½ Cr-Mo)	0.284	491
Invar (36 Ni)	0.289	499
(16-25-6 Cr-Ni-Mo)	0.300	518
(14-4 Cr-Al)	0.275	475
Hadfield and modified Hadfield	0.282	487
Triple alloy	0.284	491
Steel, tool		
18 W, 4 Cr, 1 V	0.313	541
18 W, 4 Cr, 2 V	0.313	541
18 W, 4 Cr, 1 V, 4 Co	0.312	539
18 W, 4½ Cr, 2 V, 8 Co	0.312	539
22 W, 4½ Cr, 1½ V, 12 Co	0.321	555
14 W, 4 Cr, 2 V	0.289	499
14 W, 4 Cr, 2 V, 5 Co	0.292	505
8½ Mo, 4 Cr, 1 V, 1½ W	0.289	499
5 Mo, 4 Cr, 2 V, 6 W	0.294	508
8 Mo, 4 Cr, 2 V	0.289	499
8 Mo, 4 Cr, 1 V, 2 W, 5 Co	0.291	503
8½ Mo, 4 Cr, 2 V, 2 W, 8 Co	0.292	505
1 Mo, 12 Cr	0.284	491
1 Mo, 5 Cr	0.284	491
12 Cr	0.284	491

Aluminum and Aluminum Alloys

Cast alloys

13 (12 Si)	0.096	166
40E* (5½ Zn-Mg-Cr)	0.101	175
43 (5 Si)	0.096	166
85 (5 Si-Cu)	0.101	175
108 (4 Cu-Si-Fe)	0.101	175
113 (7 Cu-Si-Fe)	0.103	178
122 (10 Cu-Si-Fe)	0.106	183
132 (12 Si-Cu-Ni)	0.097	168
142 (4 Cu-Mg-Ni)	0.101	175
195 (4½ Cu-Si)	0.100	173
212 (8 Si-Cu-Fe)	0.102	176
214 (4 Mg)	0.095	164
218 (8 Mg)	0.091	157
220 (10 Mg)	0.092	159
319 (6 Si-Cu-Fe-Zn)	0.101	175
355 (5 Si-Cu-Mg)	0.098	169
356 (7 Si-Mg)	0.097	168
360 (9½ Si-Mg)	0.095	164
380 (9 Si-Cu)	0.098	169
(7½ Zn-Mg)	0.101	175
Ingots	0.098	169

*SAE 310.

†First number is the old Aluminum Association designation and second number is the new designation.

Wrought alloys†

2S; 1100 (Commercially pure)	0.098	169
3S; 3003 (Al-Mn)	0.099	171
4S; 3004 (Al-Mn-Mg)	0.098	169
11S; 2011 (Al-Cu-Fe)	0.102	176
14S; 2014 (Al-Cu-Mg-Si-Mn)	0.101	175
17S; 2017 (Al-Cu-Mg-Mn)	0.101	175
A17S; 2117 (Al-Cu-Mg)	0.099	171
18S; 2018 (Al-Cu-Ni-Mg)	0.101	175
B18S; 2218 (Al-Cu-Ni-Mg)	0.102	176
24S; 2024 (Al-Cu-Mg-Mn)	0.100	173
25S; 2025 (Al-Cu-Si-Mn)	0.101	175
32S; 4032 (Al-Si-Cu)	0.097	168
50S; 5050 (Al-Mg)	0.097	168
A50S; 5005 (Al-Mg)	0.098	169
A51S; 6151 (Al-Si-Mg-Cr)	0.098	169
52S; 5052 (Al-Mg-Cr)	0.097	168
53S; 6053 (Al-Mg-Si-Cr)	0.097	168
A54S; 5154 (Al-Mg-Cr)	0.096	166
56S; 5056 (Al-Mg-Mn-Cr)	0.095	164
61S; 6061 (Al-Mg-Si-Cr)	0.098	169
62S; 6062 (Al-Mg-Si)	0.098	169
63S; 6063 (Al-Mg-Si)	0.098	169
75S; 7075 (Al-Zn-Mg-Cu)	0.101	175
XA75S; X7175 (Al-Zn-Mg-Cu)	0.103	178
K-18S; 5083 (Al-Mg-Mn)	0.096	166
R317 (Al-Cu-Mn)	0.101	175
EC	0.098	169

Copper and Copper Alloys

Copper anodes	0.323	558
Copper ingots	0.322	556
Copper, wrought	0.323	558
Brass, aluminum	0.310	536
Brass anodes	0.313	541
Brass castings	0.304	525
Brass, cartridge	0.308	532
Brass, commercial, castings	0.303–0.307	524–590
Brass, commercial, wrought	0.303–0.308	524–532
Brass, forging	0.305	527
Brass, free-cutting	0.307	530
Brass, red	0.316	546
Brass, yellow	0.306	529
Brass, leaded	0.306–0.308	529–532
Brass, leaded nickel	0.305	527
Brass, naval, castings	0.304	525
Brass, naval, wrought	0.304	525
Brass, admiralty metal	0.308	532
Bronze, aluminum, castings and ingots	0.274	473
Bronze, aluminum, forgings	0.284	491
Bronze, aluminum, wrought	0.281	486

Metal	Weight (lb/in.³)	Weight (lb/ft³)
Bronze, aluminum-manganese, castings and ingots	0.275–0.283	475–489
Bronze, architectural	0.306	529
Bronze, bearing		
(14 Sn, 1 Zn)	0.306	529
(19 Sn)	0.305	527
(8 Sn, 8 Pb)	0.336	581
(7 Sn, 15 Pb)	0.326–0.329	563–569
Bronze, commercial	0.318	550
Bronze, (87 Cu, 10 Pb, 3.5 P), castings	0.324	560
Bronze, hydraulic, castings and ingots	0.305–0.324	527–560
Bronze, leaded, semired	0.314	543
Bronze, high-leaded tin	0.334	577
Bronze, manganese, castings and ingots	0.292	505
Bronze, manganese, wrought	0.302	522
Bronze, ornamental, castings and ingots	0.310	536
Bronze, phosphor, castings and ingots	0.319	551
Bronze, phosphor, wrought	0.320	553
Bronze, phosphor, 1.25%	0.321	555
Bronze, phosphor, 5%	0.318	550
Bronze, silicon	0.308	532
Bronze, low silicon	0.316	546
Bronze, tin-nickel, castings	0.321	555
Bronze, valve, castings and ingots	0.315	544
Bronze (76 Cu, 6 Sn, 15 Pb, 3 Ni)	0.321–0.330	555–570
Bronze (88 Cu, 8 Sn, 4 Zn)	0.315	544
Bronze (85 Cu, 5 Sn, 9 Pb, 1 Zn)	0.334	577
Bronze (75 Cu, 5 Sn, 20 Pb)	0.334	577
Bronze (88 Cu, 10 Sn, 2 Zn)	0.315	544
Copper-beryllium alloy, castings	0.292	506
Copper-beryllium alloy, wrought	0.297	513
Copper-nickel alloy, castings	0.323	558
Copper-nickel alloy, wrought 70-30 & 90-10	0.323	558
Copper-nickel, 55-45	0.321	555
Copper-nickel-zinc alloy, castings	0.314	543
Copper-phosphorus alloy	0.323	558
Copper-silicon alloy, castings and ingots	0.312	539
Copper-silicon alloy, wrought	0.312	539
Gilding metal, 90-10	0.318	550
Gilding metal, 95-5	0.320	553
Gun metal (casting)	0.309	534
Muntz metal	0.304	525

Magnesium Alloys

Cast alloys

AZ91A (9 Al, 0.1 Mn, 0.75 Zn)	0.065	112
AZ92 (9 Al, 0.5 Zn)	0.066	114
AM100A (10 Al, 0.5 Zn, 0.1 Mn)	0.066	114
AZ63 (6 Al, 3 Zn)	0.066	114
AZ91 (9 Al, 7 Zn)	0.066	114
EK30A	0.065	112
EK33A	0.065	112
EK41A	0.066	114
Ingots and sticks	0.063	109
M1A (1.5 Mn)	0.064	111

Extrusion alloys

ZK60 (5.5 Zn, 0.5 Zr)	0.066	114

Forging alloys

AZ61A (6.15 Al, 1 Zn)	0.065	112
AZ80A (8.5 Al, 0.5 Zn)	0.065	112
M1A (1.5 Mn)	0.064	111
TA54A (3.5 Al, 5 Sn)	0.067	116

Wrought alloys

AZ61A (6.5 Al, 1 Zn)	0.065	112
AZ80A (8.5 Al, 0.5 Zn)	0.065	112
AZ31B (3 Al, 1 Zn)	0.064	111
M1A (1.5 Mn)	0.064	111
X-1 (3 Al, 3 Zn)	0.065	112

Nickel and Nickel Alloys

Nickel anodes	0.322	556
Nickel for remelting	0.301	520
Nickel, wrought	0.321	555
Permanickel (Ni-Ti)	0.316	546
"E" Nickel (Ni-Mn)	0.319	551
"D" Nickel (Ni-Mg)	0.315	544
Duranickel (Ni-Ti)	0.298	515
Nickel-copper, castings	0.312	539
Nickel-copper, wrought	0.319	551
Nickel-copper-aluminum, wrought	0.306	529
Nickel-copper-silicon, castings	0.302	522
Nickel-chromium, wrought	0.304	525
Nickel-chromium-iron, wire	0.298	515
Nickel-chromium-iron wire, Inconel "X"	0.300	518
Nimonic 75	0.302	522
Nimonic 80	0.298	515
Inconel "M"	0.298	515
Ni Span "C" (Fe-Ni-Cr)	0.290	501
Incoloy	0.290	501
Isoelastic (Fe-Ni-Cr)	0.293	506
Hastelloy A	0.318	550
Hastelloy B	0.334	577
Hastelloy C	0.323	558
Hastelloy D	0.282	487

Titanium

MST	0.166	287
MST Gr. III	0.162	280
RC-55	0.162	280
RC-70	0.162	280
RC-A110	0.160	276
RC-130A	0.166	287
RC-130B	0.165	285
RS-120	0.165	285
Ti-75A	0.162	280
Ti-150A	0.166	287

Other Metals

Antimony	0.239	413
Beryllium	0.066	114
Cadmium anodes	0.313	541
Cobalt base		
Stellite 21	0.300	513
Stellite 30	0.300	518
Stellite 31	0.311	537
S-816	0.323	558
Columbium	0.310	536
Chromium	0.260	449
Gold leaf	0.698	1,206
Lead	0.411	710
Manganese	0.268	463
Mercury	0.493	852
Silver	0.379	655
Tantalum	0.600	1037
Tin	0.208–0.264	359–456
Tungsten	0.698	1206
Vanadium	0.205	354
Zinc	0.258	446
Zirconium	0.231	399

DESIGN ABSTRACTS

When to specify

IMPACT THERMOSETTING PLASTICS

By Paul E. Fina
Fiberite Corp.
Winona, Minn.

MOLDED impact plastics should be seriously considered when the following conditions are to be met:

1. Part is to compete in toughness with durable woods and metals.
2. Part must be corrosion resistant and requires extra strength.
3. Part would require excessive, costly finishing operations in other strong materials.
4. Part needs strength plus excellent electrical and heat resisting properties.

Basic Resins: The most common types of impact molding compounds available are the phenolic, the melamine, and the polyester groups. The resin determines the basic type of material.

Basic Fillers: Impact strength of a molding compound is influenced greatly by the type of filler used in conjunction with the resin. Use of a particular filler does not result in identical properties when compounded with various resins. A filler is selected carefully to produce a certain result with a certain resin. The most common fillers employed in phenolics are listed in *Table* 1 with their Izod notch strengths.

Properties: Other properties besides impact strength must be considered:

1. Tensile, flexural, and compressive strength are usually inherent properties denoted by the type of resin. The filler will enhance these properties depending on length or size of cutting.

2. Heat resistance is obtained by using mineral filler such as glass fiber, or asbestos in long fibers, fabric or cord. Certain resins developed recently have marked heat resistant properties in themselves. Latest phenolic compounds developed for heat resistance have been known to withstand 450 F continuously. A circuit breaker base and terminal strips molded of asbestos reinforced phenolic are illustrated in *Fig.* 1.

Table 1—Izod Notch Strengths of Basic Fillers*

Filler	Izod Impact Strength (lb-ft)
Cotton or wool flock	0.4-0.6
Lightweight cotton fabric or threads	0.8-1.5
Heavy-weight cotton fabric	1.3-2.5
Cotton or nylon cord	2.8-5.0
Glass fibers	6.0-15.0
Asbestos fibers	2.0-4.0

*For any filler, percentage of filler to resin gives impact range. Intermediate strengths are obtained by lowering or raising filler content.

Fig. 1—Circuit-breaker base and terminal strips made of asbestos-reinforced phenolic

3. Wear resistance of impact materials (for those thinking in terms of bearings) can be attributed mostly to the resin. Of course, the filler is important since it also comes into contact. The toughest fillers are used, *Fig.* 2. In some cases, asbestos cord or glass fiber may be incorporated, but the bearing must not wear out the shaft.

4. Electrical properties are inherent to the resin. Two-stage phenolics, melamines and polyesters are good electrically. The better the resin-to-filler bond, the better the electrical properties, especially after water immersion. Poor bonding causes a wicking action in water within the part and destroys electrical properties. A predrying of the compound before molding and after baking of molded part reduces the volatile content, thus improving electrical properties. Again, there are several additives often used to improve results. Typical electrical values for high impact phenolics are: dielectric strength of 300 volts per mil (short time test) and available up to 600 volts per mil; dissipation factor at one megacycle (dry) of 0.48; and dielectric constant up to 6.0.

5. Resistance to chemicals is

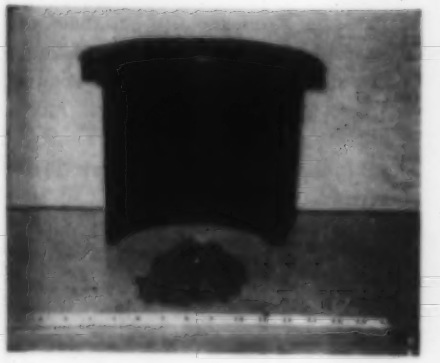


Fig. 2—Steel-mill bearing made of fabric-reinforced phenolic

basically a factor controlled by the resin type and the inert additives used. Of course, a filler such as glass fiber or asbestos is in itself resistant. The one-stage phenolics are good.

6. Torsional strength of an impact material is an intangible property. The highest strength material is not necessarily the best. As in tensile strength, torsional strength is usually decided by the amount of bond of resin to filler. The cause and effect is difficult to pinpoint, but it is guessed that molding technique is a prime factor.

7. For shock resistance (especially repeated shock), apart from what the resin may contribute, Hycar and nylon additives are known to give tremendous improvements in resiliency.

Standard Impact Designations: Army, Navy and ASTM specifications for impact plastics are listed in *Table* 2. Target objectives set up by the government, ASTM, and industry are a result of field requirements. Other properties besides impact are often involved in the range of impact plastics. Material manufacturers have also developed materials wherein there is no standard designation but a demand has been foreseen.

Use of Impact Materials: If a part is producible in hard wood, metal, masonry or structural glass, it is economically wise to investigate the range of impact plastics available, *Fig.* 3. Light weight, impact and corrosion resistance, color retention, strength requirements on electrical application, chemical resistance, and economic conditions, all are excellent reasons for considering impacts, *Figs.* 4 and 5.

Design Considerations: On the basis of general-purpose phenolic or melamine a rough criterion for impact design may be to use one-half the usual general-purpose thicknesses. Savings in material and faster curve will result. If the section is part of a vertical molded wall, thickness will depend on flowability of impact material. On vertical draw walls ⅛-inch is usually the minimum thickness to allow the filler sufficient space to flow readily during molding.

On the basis of metal die-cast parts the same sections as the die casting is a beginning criterion. Threaded metal inserts may have to be added. The difference in the molding method of impact plastics in comparison to the die casting technique will result in minor design changes. Comparison of properties will indicate where thinner sections can be employed or where an increase of section is needed.

Looking at the hard woods, we have quite a contrast in design features; for instance, considerably thinner sections to reduce bulkiness and coring and coring out of massive sections for economy may be employed. In addition, surface coats are unneeded; deterioration factors are negligible. Thus, the designer does not use the wood application as a basis for impact design.

General factors to consider in designing for impacts are:

1. Since the lighter colored impact thermosetting compounds show the filler under the surface, try

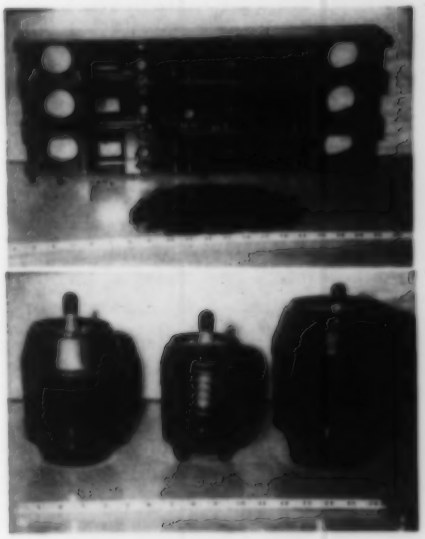


Fig. 3—Impact-plastic applications include this large breaker base, top, and a seat valve and ball, below

Table 2—Standard Impact Plastic Designations

Type or Class	Approx Izod* (lb-ft)	Filler	Remarks
U. S. Navy MIL-P-14D†			
CP15	0.6	Cotton flock	Wood flock or paper usable
CP110	1.00	Cotton fabric	Usually lightweight; threads usable
CP120	2.00	Cotton fabric	Heavy weight used
CP130	3.20	Cotton cord	Usually tire cord
CP140	4.20	Cotton cord	High per cent of cord; nylon cord usable
MP110	1.30	Asbestos	Fabric or fibrous cords
MP120	2.30	Asbestos	Strongest cord and high per cent filler
CMI5	0.6	Cotton fabric	Lightweight and high grade
MMI30	3.20	Glass fibers	.....
MAI60	8.00	Glass fibers	.....
U. S. Army MIL-P-10420 or ASTM B700-52T			
4	0.80	Fabric	Any cellulose fiber usable
5	1.75	Fabric	Usually heavy-weight fabric
6	4.00	Cord	Strongest cord used
7	0.64	Asbestos fibers	Long fibers (MIL-P-10420)
9	0.64	Asbestos fibers	Long fibers (ASTM B700-52T)
12	0.48	Paper	Block or pulp used

*Izod readings are computed for both side and face of specimen; the face side usually gives higher reading in impact materials. †Explanation of letters: First letter denotes filler, C—cellulose, M—mineral; second letter denotes plastic, P—phenolic, M—melamine resin, A—alkyd (or polyester); third letter I—impact.

to incorporate the effect as part of the design.
2. Use constant thicknesses where possible.
3. Avoid sharp corners and recesses.
4. The tiny holes and fine threads of general-purpose phenolics are not as feasible in impact plastics due to heavier grade of filler.
5. Use the lowest-strength impact plastic possible, but remember that the same mold can utilize the highest impacts.

Finishing of Molded Parts: The finishing of impact plastics could involve deflashing, machining, and painting.

A well-molded impact material normally requires only that the fibrous flash be removed from the molded part. Tumbling or blasting off of fibrous flash is not generally possible. The flash is usually filed or polished off by a hand operation (sanding belt, polishing wheels, hand files, etc.). The mold design is the criterion as to how much flash is obtained. In most cases, flash is desirable from the standpoint of good moldings. Not allowing excess flash to escape results in trapping of gases, higher molding pressure requirements, less accuracy in dimension holding, more critical weighing of charge, etc.

As to machining of impact plastics, the rule of thumb is to use the cutting of brass as criterion or guide and then adjust. With the exception of glass-filled and certain mineral-filled types, machining of higher impact-strength plastics is more readily accomplished than for lower impacts. This is due to less brittleness. If the tools are sharp and correctly ground, no fuzzy surface or chewing out occurs. Cutting speeds may be doubled, at least, with carbide tips. Lubricants or coolants are seldom needed since plastics are poor conductors of heat. It must be remembered that any machining of impact plastics results in impairment of chemical, electrical, and mechanical properties substantially over the machined area. Machine only when tolerances are too close to mold or when molding technique does not permit the incorporation of a molded hole, undercut, or design.

Cementing: If separately molded parts are to be joined, or additional inserts are to be placed in cored holes, cementing may be necessary. Glues or adhesives for wood have been used in the past. The advent of the epoxy adhesives has introduced what may be called the "miracle" cement for thermosetting materials. Several companies make available cements stronger than the molded part. Beside the epoxies, other companies are producing excellent cements of both the hot-set and cold-set types.

Coatings: Painting, spraying, electrostatic spray, silk screening, decorative surfacing, metal deposition and electroplating are readily adaptable to impacts. Because the surface appearance of impact plastic materials sometimes is not desirable, methods of resurfacing the molded product have been devised.

Surfaces to be electroplated or electrostatically sprayed must include conductor particles. Since thermosetting compounds are inherently nonconductors, a special conductive compound must be obtained from the material manufacturer. In electrostatic spraying, the parts are placed in a closed container or hood. A spray of electrically charged paint is then shot into chamber. The part to be coated is charged oppositely and attracts the sprayed particles of paint.

Surfaces can receive a decorative layer of sheet or film. Moderate success has been attained. If the sheet can be molded on in the same manner as the decorative laminates, than a good bond and excellent surface is possible. If the surface is not flat or uniformly round, then a decorative layer is not too practical. Decorative face sheets have been cemented on and have been molded in. This latter has been accomplished by opening the molding press during the curing cycle and placing the face sheet carefully so that it will not move during reclosing of press. The face sheet would otherwise tear or double up.

From a paper entitled "Impact Thermosetting plastics with Responsibilities" presented at the ASME Semi-Annual Meeting in Pittsburgh, Pa., June, 1954.

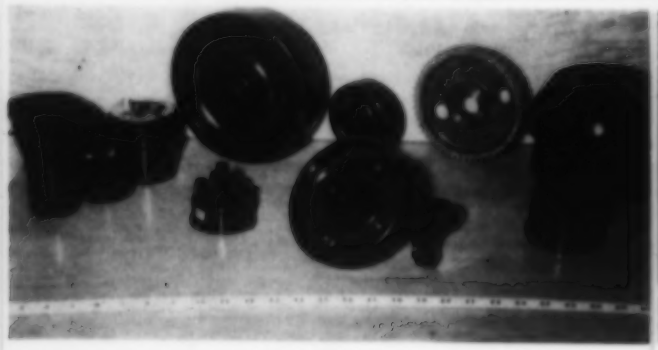


Fig. 4—Wide range of impact plastic applications is indicated by these parts, which include railroad equipment, container cap, socket, casters, timing gears and oil-well valve

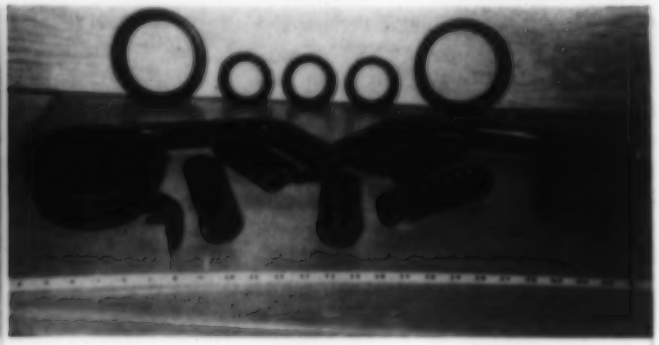


Fig. 5—New uses for impact plastics include conduit caps, shell-closing cap, welding-rod holder, timing-light housing, outboard-motor handle and fan turbine

Germanium Rectifiers

. . . provide economical dc power in a small package

By H. N. McIntyre
Application Engineer
General Electric Co.
West Lynn, Mass.

THE metallic rectifier is a static device for converting alternating current into direct current. It makes use of a highly unusual property of certain materials called semiconductors, such as selenium, copper oxide and germanium.

Allowing current to flow in only one direction, semiconductors eliminate the negative, or reverse portion, of an alternating input current. The positive portion of current passing through the rectifying material does, however maintain its pulsating nature. To get a dc output of nearly constant magnitude the current is passed through a special circuit configuration. The end result is direct current equivalent to that supplied by a motor-generator set.

There is actually no such thing as a perfect rectifying material. That is, some leakage current in the reverse direction and some voltage drop in the forward direction are always present. But for practical purposes a rectifier is considered efficient if the leakage current and forward voltage drop are extremely small.

Germanium Rectifiers: When the germanium cell is properly cooled, its load capacity is remarkable. An air-cooled cell with a rectifying surface about the size of a dime, *Fig.* 1, will handle a 2000-watt load continuously. Including heat-radiating fins, it takes up just 8 cubic inches of space and weighs only 12 ounces. Under the same cooling conditions an equivalent-rated selenium rectifier cell occupies about 330 cubic inches and weighs about 3 pounds. This is a 4 to 1 advantage in weight and better than a 40 to 1 advantage in size, *Fig.* 2.

Germanium rectifiers can be used in many applications where other devices supply large quantities of direct current. These include other types of metallic rectifiers employing, for example, selenium or copper oxide as the rectifying element. Also included are mechanical rectifiers, mercury-arc rectifiers, and motor-generator sets.

In fact, direct-current loads at almost any voltage can be supplied with a combination of germanium-rectifier "building blocks." These blocks will usually give high installation and operating economy in the ranges now covered by metallic rectifiers and motor-generator sets, *Fig.* 3.

One basic building block now in production is an air-blast-cooled germanium rectifier rated at 25 kw. This unit incorporates two 3-phase bridge circuits to provide continuous low-ripple direct current from a 3-phase power source, plus a blower for cooling and a transformer to step down input voltages.

In its present form this standard unit can be fed from any 208, 230, or 460-volt 3-phase source. Depending upon internal connections, the total continuous output would then be either 400 amp at 65 volts dc, or 200 amp at 130 volts dc. Direct-current loads of any practical voltage or current requirement can be handled by connecting the outputs of the 25-kw unit in series or parallel.

A second germanium-rectifier building block, liquid cooled instead of air-blast cooled, has an even greater size and weight advantage over other metallic rectifiers. A standard 120-kw unit, it supplies continuous dc power at 2000 amp and 65 volts and operates equally well in a corrosive atmosphere. It can be overloaded to 4000 amp for 30 seconds or to 2500 amp for 1 hour.

Efficiency: Germanium rectifiers are not only more efficient than other metallic rectifiers but also more efficient than rotary converters, with the possible exception of rotating switch-type rectifiers.

Efficiency of a 3-phase germanium rectifier is 98 to 99 per cent. Including transformer losses and power required for cooling, the overall efficiency of the standard 25 and 120-kw units mentioned before is better than 94 per cent. By contrast, more than 85 per cent efficiency with a selenium rectifier is seldom obtained and, at or below 65 volts dc, no more than this with motor-generator sets.

Germanium rectifiers are frequently operated at a current density up to 300 amp per square

Fig. 1—A germanium wafer the size of a dime is the heart of this 2000-watt rectifier cell. Complete unit weighs 12 ounces

inch of rectifying surface. Yet at this high loading, they have approximately ½-volt drop in the forward direction. On the other hand, selenium rectifiers have approximately 1-volt drop at only 0.160-amp per square inch forward loading. Based on this, a quick calculation shows that germanium can carry over 2000 times the current density of selenium with less voltage drop.

As for reverse current, germanium is again particularly good, having a reverse-to-forward resistance ratio in the order of 400,000 to 1.

Unusual Characteristics: The tremendous current density utilized as a matter of course with a germanium rectifier is possible only because of low losses within its cells. And these low losses are responsible for germanium's high efficiency. They mean savings in copper, cooling equipment, and power costs; they provide additional savings in size and weight.

But so tiny a rectifier can have

Fig. 2—Germanium rectifier cell rated at 2000 watts, left, has the same capacity but is only 1/40 the size of an equivalent selenium cell, right

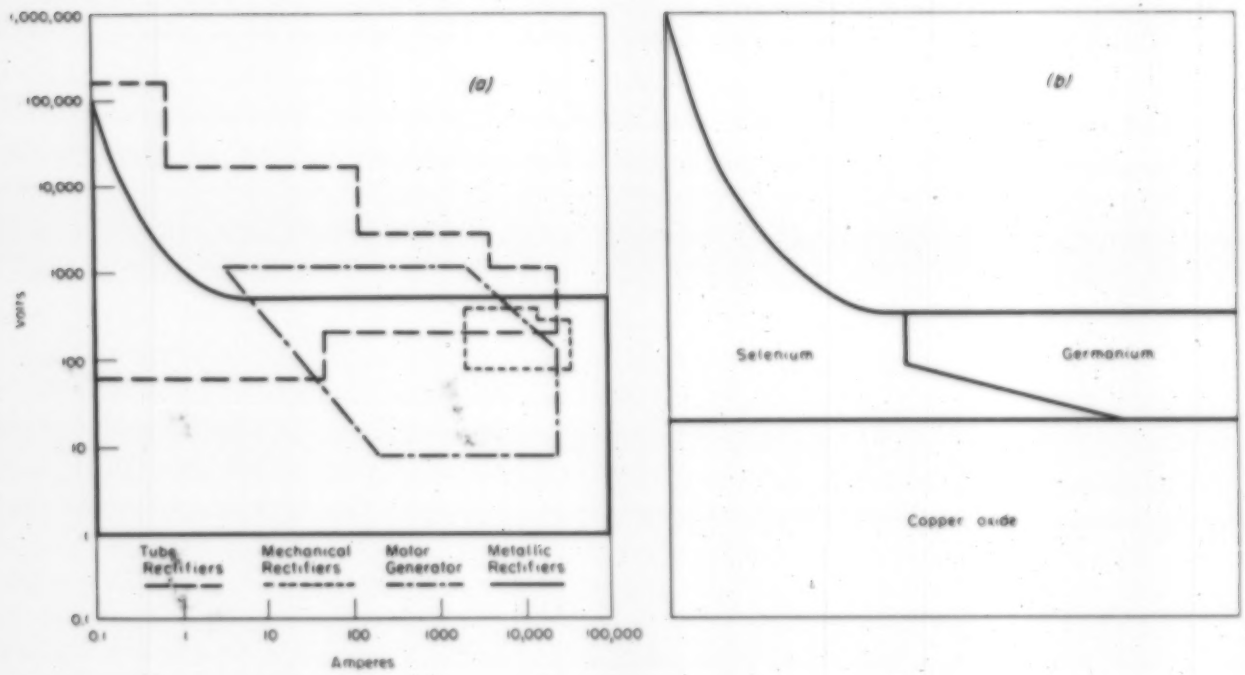


Fig. 3—Germanium rectifiers can operate over a wide range of applications. Chart *b* shows voltage and current ranges for various types of rectifying devices, while *b* illustrates relationship of approximate economical ranges for each of three metallic rectifiers

little thermal capacity. This means that the heat generated must be rapidly removed even though the losses are small. Therefore, to take advantage of germanium's other outstanding features, its low thermal capacity must be considered.

This factor is especially important if germanium rectifier cells are to be used in electric equipment of special design. Heavy overloads can produce short-time current densities that will exceed the heat-dissipating capacity of what might be considered an economically practical cooling system. As an example, a short circuit across a rectifier might burn out cells unless it were removed within about 0.005-second. Fortunately, current-limiting fuses can be used to clear the fault within a safe margin.

Another characteristic of a germanium rectifier needs explaining. During that portion of the cycle when the polarity of the input current has reversed, the rectifier is "blocking" and its resistance is extremely high. Little current then flows through the load so that for practical purposes full transformer voltage is applied directly across the rectifier cell. If the peak inverse voltage—the safe limit to which the cell can be stressed electrically—is exceeded, the cell is damaged. However, this is true of any electronic tube or capacitor, and is not a condition peculiar to germanium alone.

In practice, the established applied voltage ratings of the cells are comfortably lower than their maximum inverse peak voltages. And so, if proper design precautions are observed, no trouble with this characteristic will be experienced.

As with all metallic rectifiers, operating temperature of the germanium cell is rather critical. At present, 80 C is the maximum total temperature at which they are operated. Heat exchangers within the equipment insure that this temperature will not be exceeded under normal conditions. Where surrounding temperatures are high, liquid rather than air-blast cooling is recommended because control of cooling temperatures is much easier with a liquid.

Life: The useful life of a metallic rectifier is defined as the length of time required for its forward resistance to increase 75 per cent. For example, when operated at the current densities usually employed for power-conversion applications, high quality selenium will normally reach the end of its useful life in from 30,000 to 50,000 full-load hours.

Germanium rectifiers have been on life test in industry and in the laboratory for more than 3 years with no detectable increase in power losses. In effect, this means that there is no limit to useful life, provided rectifier rating is not exceeded. Nor is there need to adjust anything over a period of time to compensate for changes.

A rotating machine, such as a motor or generator, will last until it burns up or wears out. Depending on how well maintained, it could last indefinitely. The same seems to be true of germanium rectifiers, except that additionally they require little maintenance because they have no rotating parts other than the cooling fan.

From "Germanium Rectifiers—Big Low-Cost Power" in General Electric Review, *November*, 1954.

Review of Fundamental

Computer Mechanisms

By J. Harland Billings

Head, Dept. of Mechanical Engineering
Drexel Institute of Technology
Philadelphia, Pa.

FOR every mathematical equation there should be a mechanism or combination of mechanisms that gives the solution in any desired range. This is probably true, but discovery of the required mechanisms or combinations is not always easy. In the following examples the adaptation of mechanisms to perform the simpler mathematical operations will be reviewed.

Addition and Subtraction: The simple device of *Fig.* 1 consists of two or more rollers contacting upper and lower movable bars, r and t, and through their supporting bearings controlling the movement of the center bar s. It represents by its possible motions the equation

$$r + t = \frac{s}{2} \qquad (1)$$

It can therefore be used for the

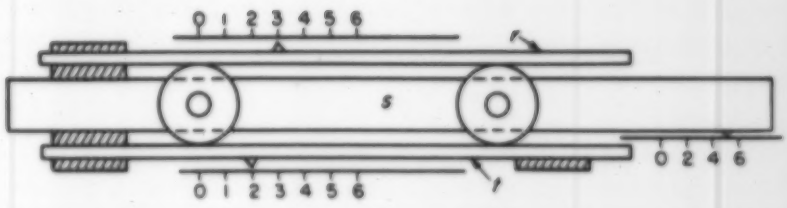


Fig. 1—Device for addition and subtraction has rollers transmitting motion to center bar s from upper bar r and lower bar t

addition of two variables to the scales indicated. Obviously the operation of subtraction can also be performed.

In practical application, light spring pressure is generally applied so that the pressure between rollers and bars will prevent slippage. If considerable resistance to the motions exists, the rollers may be made pinions and the bars racks. It has been found, however, that smooth rollers and bars held together by light spring pressures are remarkably free from slippage where the forces involved are small. Larger forces can always be transmitted by the use of servomotors.

The familiar differential gear mechanism of *Fig.* 2 has the same fundamental properties as the bar and roller mechanism just considered, except that the relative motions of the three elements r, t and s are rotation instead of translation. It mechanizes the expression

$$N_r + N_t = \frac{N_s}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where N is revolutions in unit time.

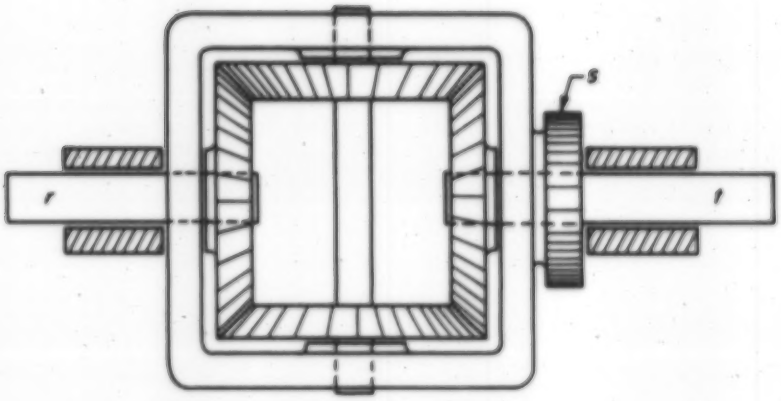


Fig. 2—This differential gear mechanism adds and subtracts through relative rotation of elements r, t and s

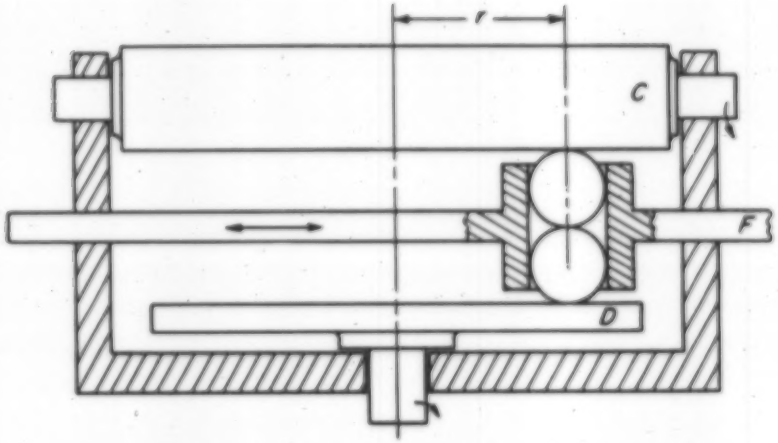


Fig. 3—Integration is accomplished with this roller and disk arrangement. Rate of rotation of disk D and axial displacement r of the balls are controlled variables. Rotation of roller C is the resulting variable

Integration: The common brush-wheel mechanism or roller and disk, as it is sometimes called, is a natural integrator. A practical difficulty in adapting this device for computer purposes is the resistance to sliding the roller axially on the disk, since the roller must be pressed against the disk to prevent lost motion. This difficulty has been overcome for computer application by the construction shown in *Fig.* 3. Here, the single roller has been replaced by two balls which are supported in a cage in link F so that the centers of the balls are always in a line normal to the contact surface of disk D.

Where maximum elimination of friction is required, small rollers may be supported in bearings in the cage at four points of contact between each ball and its cage. With this arrangement there is very small friction opposing the movement of link F even though disk D is stationary.

The controlled variables are generally the rate of rotation of disk D and the axial displacement of the balls, r. Then the rotation of C is the resulting variable. The action of the mechanism gives the relation

$$dL_c = r d\theta_D \text{ or } L_C = \int r d\theta_D \quad \ldots (3)$$

where L_C is the linear movement of the surface of cylinder C, and θ_D is the angular movement of disk D. If C is replaced by a plate or bar, the output will be obtained as a linear quantity in which case the integrator could only be used where required travel would be short and reversing.

Multiplication and Division: For all possible positions of the multiplying and dividing mechanism, *Fig.* 4, from similar triangles,

$$\frac{y}{x} = \frac{t}{b} \text{ or } y = \frac{tx}{b} \quad \ldots\ldots\ldots (4)$$

If t and x are fed in at the scale 1 in. $= m$, then b should be measured to the same scale and the product tx will be given at y to the scale 1 in. $= bm$. Division may be accomplished according to the relation

$$\frac{y}{t} = \frac{x}{b} \text{ or } \frac{y}{x} = \frac{t}{b} \quad \ldots\ldots\ldots (5)$$

The ball and disk mechanism of *Fig.* 3 is also a handy multiplier, giving $L_C = r\,\theta_D$. It is subject to

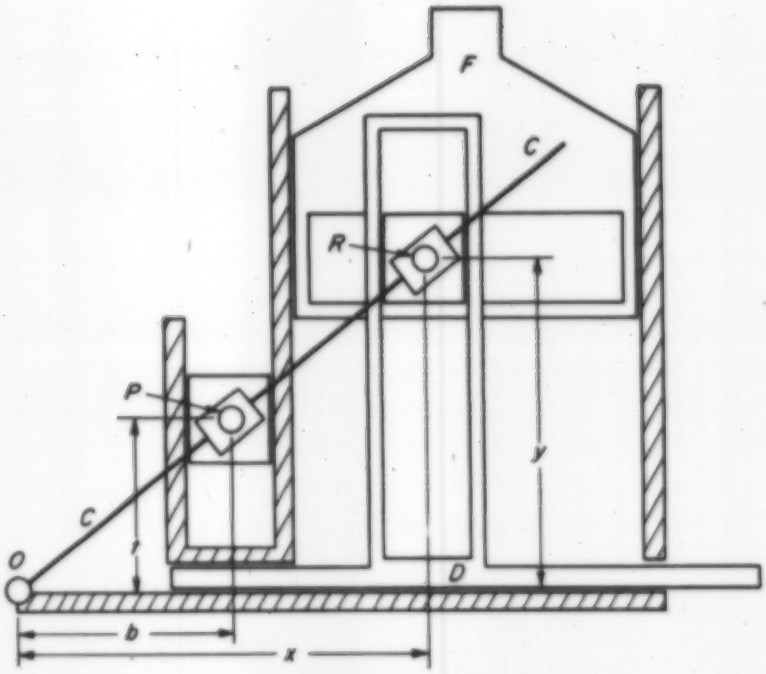


Fig. 4—In multiplying and dividing, bar *C* slides through block at *R*. Slider *D* moves horizontally by the amount of variable *x*, carrying pin *R*, which is also positioned vertically through link *F* by the amount of variable *y*. Pin *P* travels vertically the amount *t*, while bar *C* slides through the smaller block at *P*. Thus *b* is constant

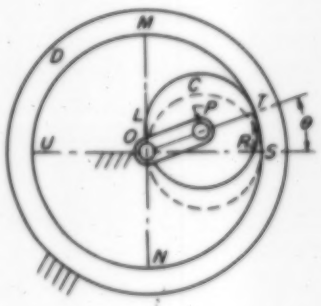


Fig. 5—Sines and cosines are expressed by this device consisting of bar *OP* pivoted at *O* with roller *C* carried at *P*. The roller makes rolling contact with the inside of fixed ring *D*. Diameter of roller is one half inside diameter of ring. As roller moves from *S* to *T*, point *R* on roller indicates cosine of angle θ by distance *OR*. Distance *OL* indicates sin θ

the limitation, however, that while *r* may be selected, it must be held constant throughout each multiplying operation.

Trigonometric Functions: In the operation of computers it frequently becomes necessary to feed in the varying effects of changing angles in terms of the trigonometric functions of the angles. Devices are therefore necessary which will express the trigonometric functions as linear quantities. The mechanism of *Fig.* 5 will do this for the sine and cosine.

Bar *OP* is supported at one end by a turning pair with the frame, and at the other end, carries a roller which makes contact with the inside of the fixed ring *D*. If the roller has diameter equal to one-half the inside diameter of the ring, all points on its circumference will travel on straight diametral paths with respect to the ring. It is assumed that there will be good rolling contact between roller *C* and ring *D* without sliding and, of course, gear teeth may be used if necessary. As rolling contact moves from *S* to *T*, a point attached to the roller would move from *S* to *R* and $\cos \theta = OR/OT$. For any value of θ, the distance from *O* to *R* measures the cosine to the linear scale $OS = 1$.

In similar manner, a pin attached to roller *C* at *L* and traveling on diameter *MN* will measure sine θ by its distance from *O*.

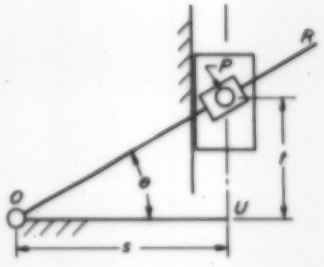


Fig. 6—In this mechanism, the tangent of angle θ is indicated by distance *t*, since *s* is constant

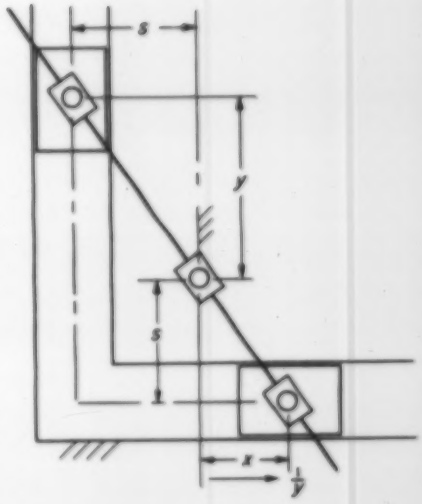


Fig. 7—Inversions are expressed by this mechanism, in which the inclined bar slides through the upper and lower guide blocks, constrained to vertical and horizontal motion respectively. From similar triangles, *x* is to *s* as *s* is to *y*

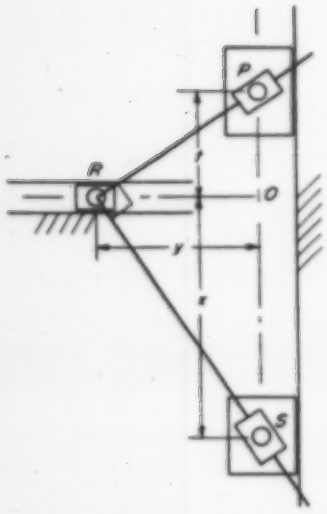
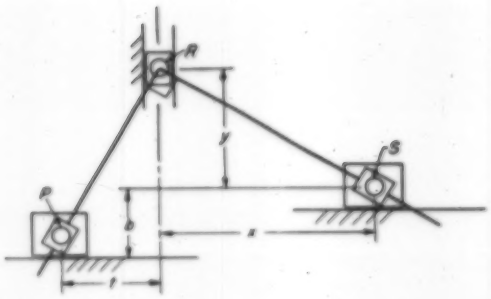


Fig. 8—Angle bar *PRS* is always a right angle in this mechanism for finding squares and square roots, where $y^2 = tx$

A simple tangent mechanism is shown in *Fig.* 6 where the bar *R* is free to slide through the small guiding block while the pin at *P* is constrained to vertical travel by the larger slider. Tan $\theta = t/s$ and, since s is constant, tan θ is measured by the changing distance t to the scale s in. = tan 45 degrees or 1 in. = $1/s$.

Inversions: In *Fig.* 7 the inclined bar is free to slide through the upper and lower guide blocks which are in turn constrained to vertical and horizontal motion respectively. The bar does not slide through the center block. From similar triangles $x/s = s/y$, or $x = s^2/y$, where s is constant. The value $1/y$ can be measured on the x scale to the scale of 1 in. = $1/s^2$ in. This mechanism also makes it possible to evaluate for computer purposes cosec θ, sec θ and cotan θ from sin θ, cos θ and tan θ when used in combination with the mechanisms of *Figs.* 5 and 6.

Fig. 9—Angle-bar and slider combinations can be arranged to solve quadratic equations. Legs of the angle bar are free to slide through the small blocks at *S* and *P* as variables x and t are fed in. Distance b is constant



Squares and Square Roots: *Fig.* 8 shows an angle bar such that angle *PRS* is always a right angle. This combined with the constrainment of the three sliders produces the relations

$$\frac{y}{x} = \frac{t}{y} \text{ or } y^2 = tx \quad \ldots\ldots\ldots (6)$$

where x, y and t are variables. Feeding in any two, the mechanism solves Equation 6 for the third. The scales are direct reading since no constants are involved. All scales are zero at point *O*.

Next consider the effect of fixing t, which is accomplished by fixing the pin at *P*. The result is a square and square root relation such that y^2 is delivered on the x dimension to the scale 1 in. = t. If x is fed in, the square root of x is delivered by the y dimension to the scale 1 in. = $1/(t)^{1/2}$.

Quadratics: The angle-bar and slider combination can also be arranged to solve equations of quadratic form, *Fig.* 9. The legs of the square link are free to slide through the small blocks at *S* and *P* as the variables x and t are fed in, *R* being constrained to a locus normal to the paths of *S* and *P*. From the nature of the mechanism,

$$y^2 + yb - tx = 0 \quad \ldots\ldots\ldots (7)$$

where x, y and t are variables and b is a constant. By placing the large block at *P* in a vertical slide, t can be fixed and b made variable. In fact, any three of the four quantities can be made supplied variables and the other becomes the solution. Adaptation to a variety of physical problems is possible.

From a paper entitled "The Kinematics of Computers" presented at the Summer School for Engineering Teachers of the American Society for Engineering Education, University of Illinois, Chicago, June, 1954.

Solid Particles in Oil

By H. G. Rylander and E. M. Wight

University of Texas
Austin, Texas

BEARING and shaft surface finish are of prime importance. The critical ZN/P, or "bearing modulus," of a given bearing may be lowered by an amount approximately proportional to the improvement of surface finish, *Fig.* 1. A mild abrasive, such as fine rouge, added to the oil will improve the bearing and shaft surfaces during operation, *Fig.* 2. Under certain conditions, bearing load capacity can be more than doubled by using small amounts of rouge in the oil.

Friction is virtually independent of roughness when the bearing operates in the region of film lubrication. A combination of an ex-

JOHNSON SLEEVE BEARINGS WILL HELP LOWER YOUR PRODUCT COSTS

The cost of sleeve bearings is very low in comparison with other types. In most applications, they will give long, uninterrupted, economical service. As Johnson Bearings are made in a variety of styles and a selection of alloys and metal combinations, there is one for every use. If you are interested in keeping down your product costs, investigate. Write today.

JOHNSON BRONZE COMPANY,
525 S. Mill St., New Castle, Pa.

JOHNSON B BEARINGS
Sleeve Type

tremely smooth shaft and bearing may reduce friction slightly.

Molybdenum sulphide possesses good antiseizing properties and can lower the critical ZN/P, but it does not lower the coefficient of friction in the region of film lubrication. It is most effective on copper-lead with an increase in load capacity of 60 per cent.

Both copper-lead and aluminum bearings have very poor embedability characteristics as compared with babbitt. Friction values for aluminum and copper-lead are as much as 7½ times those when operating with small amounts of 22-micron corundum.

Aluminum bearings withstand metal-to-metal contact at high temperatures better than babbitt and copper-lead, which wipe the babbitt or lead into the oil grooves.

Very rapid wear may take place with small concentrations of hard sharp particles. The harder bearing materials are no improvement over babbitt as far as wear is concerned. Oil discoloration does not indicate the friction or wear to be expected.

Good filtration is much more important when using the harder bearing materials of aluminum and copper-lead than when using babbitt. Particles as small as 6 microns cause friction increases five times normal.

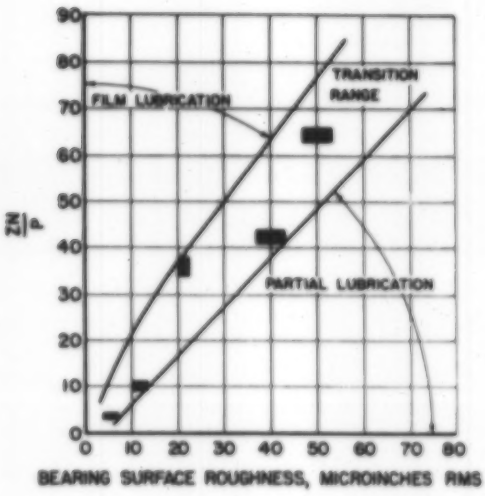


Fig. 1—Variation of lubrication characteristics with bearing surface roughness: Z = oil viscosity, centipoise; N = shaft speed, rpm; and P = bearing pressure, psi

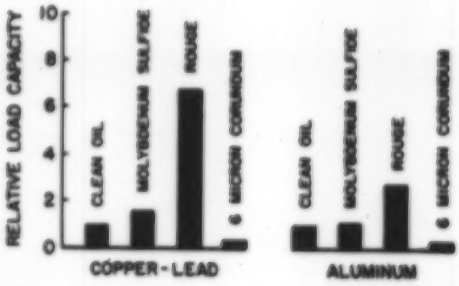


Fig. 2—Relative bearing load capacities, assuming oil viscosity and shaft speed constant

From a paper entitled "The Influence of Solid Particles in the Oil to Babbitt, Copper-Lead, and Aluminum Bearing" presented at the ASME Fall Meeting, Milwaukee, Wis., September, 1954.

When to use

Cast-Weld Construction

By G. J. Gibson

Project Engineer
Cooper Alloy Corp.
Hillside, N. J.

THE process of making castings in sections and welding them together should be considered:

1. When the designer has followed all the rules and has eliminated as many of the undesirable features as possible.
2. When the molder has used up all the available space with chills, gates and risers, and there are still unfed hot spots in the casting.
3. When large awkward coring can be eliminated or substantially reduced.
4. When long relatively slender castings are required. Welding can often be used to advantage in joining several cast sections together. Savings are sometimes made in using the same pattern for duplicate sections; shorter flasks are required; and dimensions and straightness are under better control.
5. When comparatively thin sections of large areas are involved, a rolled plate section can be incorporated in the casting by welding; and the centerline shrinkage, to which such castings are subject, can be avoided.
6. When there are details in the nature of attachments which would complicate the molding of the main section of the casting or the drawing of a pattern, it is simpler to attach them later by welding.

It is not practical to list all possible applications where cast-weld construction can be used economically. The important thing is to keep joining by welding in mind as a possible solution to unusual

Here's How

GITS

Helps Give

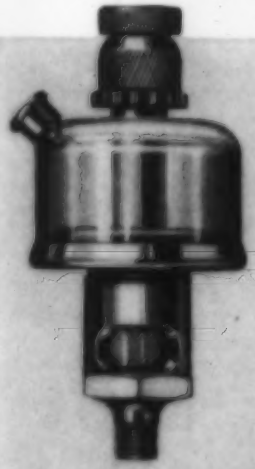
Built-In Low Cost To YOUR Equipment

OIL HOLE COVERS

This model is designed to fit into a simple drilled hole. Ideal for use on small motors, generators, starters and light machinery—for dependable oil hole protection at moderate cost. Larger sizes frequently used as filler caps on tanks or reservoirs. Style R—No. 305.

OIL CUPS

curately machined from a d brass one-piece forging. oil cup permits safe, de- dable application of lubri- t at very low cost. Used ely on motors and small ma- nery requiring side oiling. le L—No. 1202.



SIGHT GRAVITY FEED OILERS

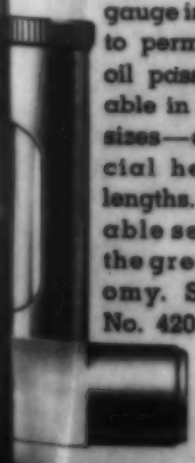
Rate of oil flow regulated by needle valve, directly observed through sight glass in stem. Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.

GEAR CASE GAUGES

This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.

ORGED BRASS GAUGES

avily constructed in a single ce from forged brass — this gauge is also drilled to permit generous oil passage. Available in many stock sizes—and in special heights and lengths. For dependable service with the greatest economy. Style FG—No. 4204.



SIGHT GAUGES

For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

Don't price yourself out of the market. When you design proper lubrication into your equipment, specify GITS Lubricating Devices—the widest selection available anywhere. The items pictured above are only a few of our many thousands of lubricating devices. At the design stage, get the GITS story. Free Engineering Service. Send NOW for your free Catalog.

GITS BROS. MFG. CO.

The Standard For Industry For Almost Half A Century

1868 South Kilbourn Avenue
Chicago 23, Illinois

Clip this page for handy "rough reference"

problems.

Locating the Weld: The first consideration in locating the weld is to satisfy objectives of good welding practice. If there is any choice in locating the joint it should be where welding will be at a minimum. The cost of stainless-steel weld metal in place, for example, will average about $7.00 per pound. The type of joint and size of weld must be adequate from a stress standpoint, but it is not economical or practical to make all welding joints look like part of the casting.

Accessibility for welding and fitting of parts must also be considered in location of the joint. A welder must be able to see the point of welding and at the same time be able to touch the bottom of the joint with his electrode angled not more than 45 degrees from the plane of the joint.

Fitting of rough castings for welding is complicated by rough casting tolerances and allowances left for machining. If there is a large duplication of pieces, a fixture should be worked out so that the relative position of the parts is located without measuring for assembly by tack welding. Some casting parts are naturally self-aligning and the designer should incorporate such features if possible. A good example of a self-aligning joint is a socket type pipe joint. Some types of castings, particularly pressure types, require machining before welding, in which case the fitting problem is easier. In any case the part drawing should show all information required for fitting, as well as exact size and design of the joint.

Types of Weld: Fillet welds are the simplest type, *Fig.* 1. These are used to connect two members which intersect at right angles, such as stiffeners and other attachments. Fillet welds require no special edge preparation but their size is important. Quantity of weld metal increases as the square of the fillet size, while the strength of a fillet weld is based on its throat section.

Most cast-weld construction results in a butt type joint, *Fig.* 1. The two members may be in line or at right angles to each other. Butt joints of two equal thicknesses should have complete penetration and be welded from both sides if possible.

Butt welds of pressure castings —those containing a liquid or gas —can usually be welded only from the outside, but there are special means of getting complete penetration. Some members are completely surrounded by a corrosive media, so they must be welded all around to leave no pockets for concentration cell corrosion.

Bevel groove joints are most commonly used for butt welding. The maximum practical depth of groove that is beveled from only one side is ¾-inch. Over this thickness beveled joints require excessive weld metal and become uneconomical. When thicker material is encountered, the joint should be beveled from both sides.

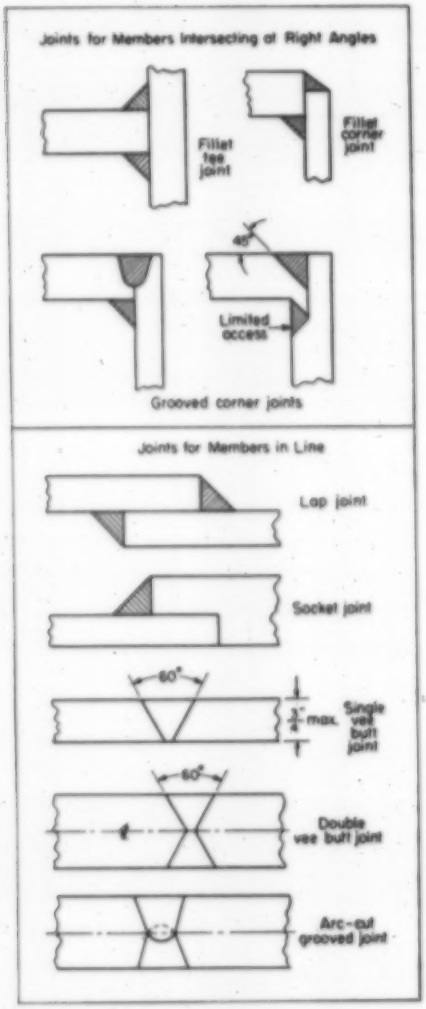


Fig. 1 — Typical welded joints used in cast-weld construction

When a heavy flange is to be attached to a thinner section, the flange should be beveled only to depth equal to the thinner section. However, allowance must be made for the amount of metal removed by machining so that there is sufficient weld left for stress requirements.

Bevels on castings may be cast or machined but machining is an additional operation and is usually undesirable. A joint that is beveled from both edges should have a 60-degree groove, but when only one edge is beveled, a 45-degree bevel is preferable.

It is important for a designer to take advantage of all the new tools and methods used in foundries. One such new process consists of carbon-arc cutting in a blast of air. The method consists of butting up unprepared ends of members and tack welding them together. One side of the joint is cut out in the form of a "U" groove which is generally the most desirable shape for butt welding. After one side is welded, the opposite side of the joint is grooved down to sound weld metal and then welded.

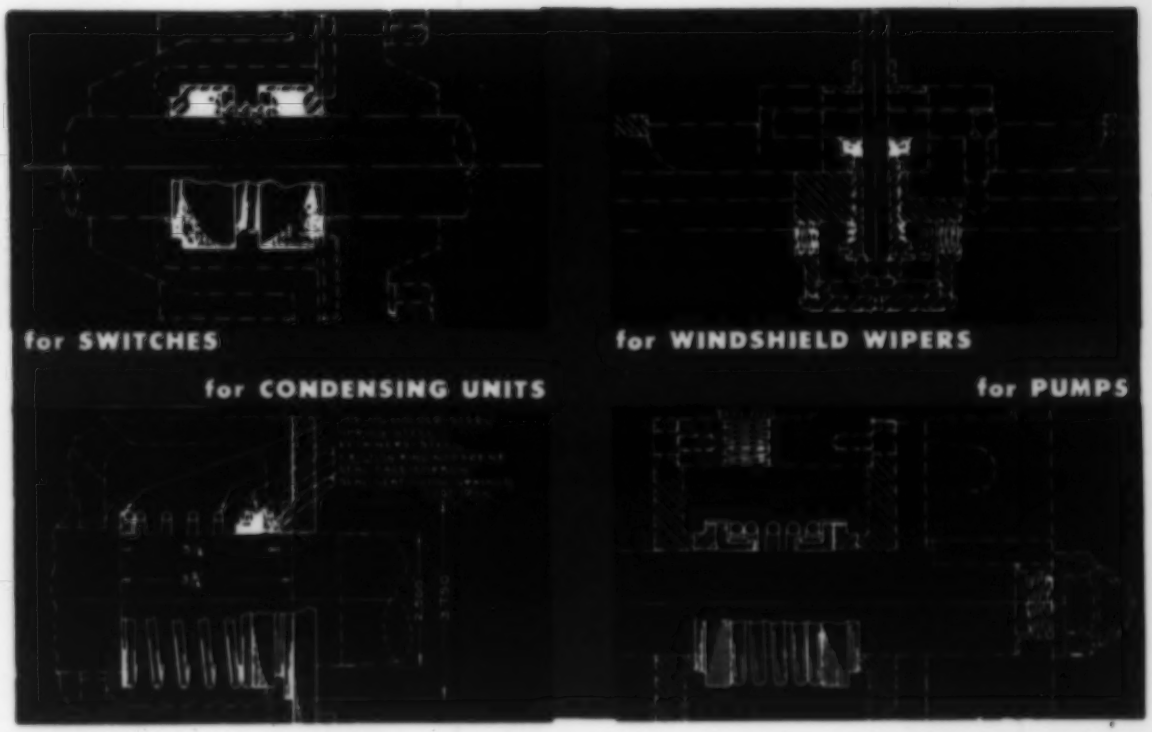
The carbon-arc air blast cutting operation is clean and results in very little heating of the casting. All the melted metal is continuously blown away so there is no danger of contamination with carbon. If there are any defects in the casting which might interfere with welding, they will show up and can be removed while cutting. With this method of groove preparation the designer simply has to specify the depth of the weld.

Automatic weld-metal deposition rates are 2 to 4 times those of manual arc welding and have the advantage of continuous deposition so that labor costs are considerably reduced. On the other hand, motorized welding positioners or special welding jigs are usually required, so that considerable duplication is required to make automatic welding worthwhile.

From "Factors in Designing Cast-Weld Construction" in Cooper Alloy Corp. Newscast, October, 1954.

Stuck for the Right answer to a Shaft-Sealing problem?

TURN TO... ROTARY SEALS



When ordinary methods won't do the job—yet *Shaft-Sealing Certainty* is a *must*—the proper ROTARY SEAL is usually the answer. ROTARY SEALS stop Shaft-Sealing troubles before they start, because they're *tailor-made* for each specific application.

The basic sealing principle originally introduced by ROTARY SEAL more than 20 years ago has naturally been imitated up to a point. But the broad experience of ROTARY SEAL engineers is inimitable. That experience makes it possible to adapt the basic ROTARY SEAL principle in just the right way—with the correct facings, springs and other details—to give you complete assurance of positive, trouble-free Seal performance under *your* conditions.

The illustrations above suggest only a few of the many successful uses of ROTARY SEALS. You'll find them "standard equipment" among leading makers of PUMPS—HYDRAULIC DEVICES—COMPRESSORS — APPLIANCES — GEAR BOXES—HEAVY DUTY WINDSHIELD WIPERS—AGRICULTURAL MACHINERY—and in scores of other applications where *Shaft-Sealing Certainty* is vital even under the most rigorous conditions.

The best time to start solving *your* Shaft-Sealing problem is at the drawing-board stage. Call in our engineers for an early consultation—and send for your copy of our brochure, *"Sealing with Certainty"*, which explains and illustrates the ROTARY SEAL principle.

THE ROTARY SEAL COMPANY — mechanical seals for rotating shafts

Shaft-Sealing with Certainty

2022 NORTH LARRABEE STREET
CHICAGO 14, ILLINOIS, U.S.A.

Helpful Literature

(Continued from page 224)

spacing, parallelism, helix angle, backlash and other factors of gears. Unit can be used also on worm gears, worm wheels, threaded parts and for measuring diameters and dimensions. Full information is given in 12-page illustrated catalog.

37. Precision Switches

Minneapolis-Honeywell Regulator Co., Micro Switch Div.—28-page illustrated catalog No. 62 gives details of ten classifications of Micro Switch phenolic enclosed, precision snap-action basic switches, including those with high electrical capacity, high sensitivity, single-pole, double-pole, double break and split-contact arrangements. Over 400 listings of basic switches, auxiliary actuators and terminal enclosures are covered.

38. Standard Worm Gear Sets

Foote Bros. Gear & Machine Corp.—Engineering Manual SW No. 1 is a 24-page compilation of data on standard worm gear sets in standard ratios from 4¼:1 to 71:1. Tabulated are horsepower ratings and efficiencies. Dimensions, part numbers, load characteristics, selection guidance and helpful design suggestions complete this useful guide book to worm gear sets.

39. Solids Pump

Western Machinery Co.—What is described as a "revolutionary new concept in materials handling" is incorporated in the new Wemco Torque-Flow solids pump. Capacities range up to 4000 gpm. Recessed impeller creates vortex effect which causes pulp in main pump body to rotate and develop suction and pressure heads necessary for pumping. Because impeller is out of main flow, any liquid-solids combination that will pass through piping can be pumped. Ask for bulletin SP-10.

40. Sealed Ball Bearings

Marlin-Rockwell Corp.—Complete dimensions, limiting speeds and other data on line of single and double sealed Synthe-Seal ball bearings in OD sizes from ½-in. to over 5½ in. are given in 4-page bulletin 1528. Removable synthetic rubber seal excludes dirt, grit and moisture.

41. Electric Control Checker

W. F. & John Barnes Co.—8-page illustrated bulletin "Electro-Graphic Detector Systems" describes recent development for simplifying the maintenance of complex electrical control. This wired-in checking system consisting of separate electric circuits wired to schematic electrical diagrams facilitates servicing and maintenance in design and building of automation equipment.

42. Bellows & Flexible Metal Hose

Flexonics Corp.—Flexon bellows of stainless steel, Monel, brass and bronze as well as convoluted and corrugated types of flexible metal hose are subjects of 16-page illustrated Product Design catalog 145. Specifications, applications, engineering data and all information required by designers are given in usable form.

43. Air-Hydraulic Cylinders

Galland-Henning Mfg. Co., Nopak Div.—Low pressure cylinders for service up to 650 psi maximum are subject of illustrated catalog 101. Covered are dimensions, operating characteristics, pressure ranges and other data.

44. Steel Pulleys

American Pulley Co.—Illustrated and briefly described in 16-page brochure are the manufacturing techniques and personal skills required to produce steel pulleys for material conveying, power transmission, railroad car lighting, heating and air conditioning and for textile machinery.

45. Clutch Plates & Brake Linings

S. K. Wellman Co.—Two illustrated catalogs cover additions to line of Velvetouch all metal clutch plates, facings, automatic transmission disks, and brake linings. Catalog No. 55-T covers replacement friction parts for tractors and industrial equipment, while the other, No. 55-A, lists parts for trucks, busses and automobiles.

46. Toggle Clamps

Detroit Stamping Co.—De-Sta-Co toggle clamps described and illustrated in 16-page catalog 52-A are offered in more than 40 sizes and types. Clamps feature fast clamping, positive holding and instantaneous release of workpieces. Styles covered include horizontal clamps from 375-lb holding capacity, portable plier clamps and heavy duty plunger types with up to 4000-lb capacity.

47. Flexible Couplings

Ajax Flexible Coupling Co.—Pocket-size selection guide contains technical data, ratings, drawings, specifications and service factors, plus information on various uses of rubber-bronze bushed flexible couplings. Variety of types are for bores from ⅛ to 15 in., 8000 to 840 rpm and 77 to 89,250 ft-lb torque. All are covered in 16-page bulletin No. 57.

48. Air Motors, Compressors, Pumps

Gast Mfg. Corp.—"Original Equipment Application Ideas for Product Designers" is an illustrated 12-page booklet (1054-37) which shows how 35 product component problems were solved with Gast rotary air motors, air compressors, and vacuum pumps. It contains photos of applications and detailed captions. Names of companies are also given.

49. Steel Sheaves

Farrell-Cheek Steel Co.—Improved carbon and "85" alloy cast steel sheaves with "cable saver" grooves are described in illustrated 4-page form 40M. Grooves are free of fins and abrasives and are smooth and highly finished. They are made to specifications with any type of bushing or bearing.

50. Fluid Cylinders & Valves

Modernair Corp.—Range of fluid power cylinders, valves and packaged devices available in Modernair line is shown in 4-page illustrated brochure CB. Highlights of company facilities and achievements are given and several typical applications of the devices are described and illustrated.

51. Aluminum Products

Kaiser Aluminum & Chemical Sales, Inc.—Illustrated wall chart lists line of new aluminum products offered by this company. Included are rectangles; squares; structural shapes, including equal and unequal angles, channels and I-beams in 25-ft lengths; round, square and rectangular tubing; and ASA schedule 40 pipe. Available alloys are listed.

52. Selenium Rectifiers

Fansteel Metallurgical Corp.—Line of high temperature selenium rectifiers designed to operate continuously at room temperature ratings in ambient temperatures up to 100° C is subject of 4-page illustrated bulletin 6.401. With moderate derating they may be used up to 150° C. Listed are 86 types and sizes, their output ratings, life, voltage drop and other data.

53. Torque Converter Couplings

Fuller Mfg. Co.—Up to 2.1 to 1 torque multiplication with automatic adjustment to 1 to 1 coupling operation as torque demand drops is delivered by torque converter couplings described in illustrated 6-page bulletin. They are offered in three models for use with engines developing 180-225 lb-in. of torque governed at 2000-2200 rpm or higher. Performance and engineering data for various types of installations are given.

54. Armored Motors

General Electric Co.—Performance and maintenance features of heavy duty armored motors (direct current types MD and MDP, 600 series) are presented in 20-page illustrated bulletin GEA-4654C. Included are units with horsepower ratings from 5 to 600 and mechanical data. Diagrams and photos show various applications.

55. Stainless Mechanical Tubing

Babcock & Wilcox Co., Tubular Products Div.—"B & W Seamless or Welded Stainless Mechanical Tubing" is a 6-page illustrated folder (TB 385) which outlines advantages offered to design and fabrication engineers who consider tubing in the production of parts and products. The many finishes, size range, types and shapes offered, plus tables of properties and processing data, are covered.

56. Nickel Wire, Rod & Strip

H. K. Porter Co., Alloy Metal Wire Div.—Engineering properties of nickel alloy wire, rod and strip are presented in this wall chart which folds into a 8½ x 11-in. booklet. Properties for nickel, Monel, Inconel, Incoloy and nickel-clad copper are given.

57. Nickel Cast Irons

International Nickel Co.—Fifty illustrations, 27 tables, charts and photomicrographs and much factual data are used in 28-page bulletin A-69 to present the characteristics and indicate the wide usage of nickel cast irons. Engineering properties of cast iron, alloyed with nickel along or in combination with other alloying elements, can be controlled to meet specific service requirements. Physical and mechanical properties of alloys are given.

58. Metal Protection Chemicals

American Chemical Paint Co.—Description of chemicals and processes for metal protection and paint bonding is found in 4-page folder 3d/Am. Included are data on processing of aluminum with Alodine, zinc, galvanized iron and cadmium with Lithoform and steel with Granodine. Brush, dip and spray processing are covered.

59. Heavy Duty Pumps

Viking Pump Co.—Engineering and design details, application data and detailed specifications on 10 to 1050-gpm rotary pumps are given in 26-pages of spiral plastic bound catalog section C. Covered are Multi-Ring, Roto-Ring, unmounted, gear drive, V-belt drive, Straitline, double gear drive, combination V-belt and gear drive heavy duty pumps. Wide range of capacities and construction materials is offered.

60. Screw-Lock Insert

Heli-Coil Corp.—Selection tables, line drawings showing proper installation in blind and through holes and instructions on use of Heli-Coil screw-lock inserts are found in 4-page bulletin 715-A. Similar to standard stainless steel insert, it has added feature of constricting grip-coil at the bottom of the insert which eliminates need for other locking devices.

61. Split Ball Bearings

Split Ballbearing Corp.—Load and speed ratings, design data, dimensions and other information on complete line of split ball bearings are presented in 24-page illustrated catalog No. 54. Covered are single and double-row ball bearing bushings with extra-thin section, split heavy duty pillow blocks, ball and roller bearings, thin section instrument bearings and heavy duty metric series ball bearings.

62. Titanium Tubing

Superior Tube Co.—Up-to-date information on fabrication of unalloyed titanium tubing, including heat treating, pickling, welding, brazing and machining data, are found in 8-page illustrated bulletin No. 43. Section on applications is included. Advantages listed include light weight, high strength, corrosion resistance, good ductility and others.

63. Subminiature Switches

Minneapolis-Honeywell Regulator Co., Micro Switch Div.—Environmentproof subminiature precision switches of snap-acting type, made in variety of types with various contact materials, are described in illustrated data sheet P96. Operating range is —65 to 180° F and operating force is 5 to 17 oz.

64. Pilot Lights

Dialight Corp.—Subminiature pilot lights described in illustrated brochure L-157 of 4 pages are one-terminal type for use on grounded circuits. Five types of units are described. Dimensions, technical data and list of lens colors available are included. Terminals may be soldering or binding screw type.

BALTRIC...

THE MOTOR THAT COULDN'T BE BUILT BEFORE

Now, in a complete line of totally enclosed motors, Baltric brings you the best answer yet to your motor problems. Less weight . . . less bulk . . . better performance, are the results of advanced engineering and new and better materials.

The new Baltric Motors pack much more power per ounce . . . permit applications and installations of greater versatility. Simple in design, rugged, yet compact and dependable, Baltric does a better job in less space than old-style motors. Baltric is a better bet for every use.

Baltric Motors are available in a complete range of models, ⅛ h. p., through 5 h. p., squirrel cage induction type, both polyphase and single phase. Baltric Motors can also be engineered to meet your special mechanical and electrical requirements.

Original *Streamcooled* Baldor Motors Available—Built to Former NEMA Standards

ALL BALTRIC MOTORS TOTALLY ENCLOSED AND *STREAMCOOLED*

BCSS-3

ALDOR ELECTRIC COMPANY

Baltric Motors Are Available in Polyphase
Squirrel Cage · Induction and Single Phase
Capacitor Start · Induction Run Types

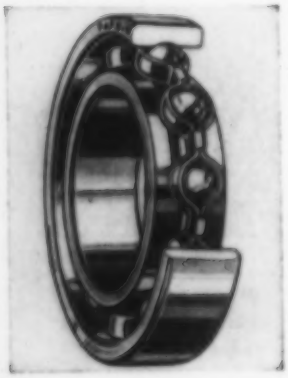
4353 DUNCAN AVENUE • ST. LOUIS 10, MISSOURI

NEW PARTS AND MATERIALS

For additional information on these new developments, see Page 223

Lightweight Bearings

For applications where space and weight are limited, series M9300K light-section, large-bore bearings handle light to moderate radial loads and moderate thrust loads in either direction. Bearings are currently available in 23 sizes,

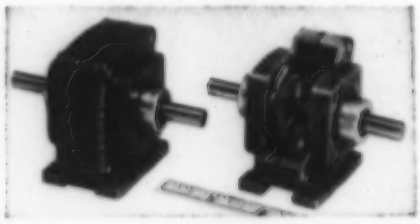


ranging from 0.3937 to 4.3307-in. bore, 0.8661 to 5.9055-in. OD and 0.2362 to 0.7874-in. width. Load ratings of the various sizes range from 465 to 6590 lb at 50 rpm to 100 to 557 lb at 5000 rpm. Made by **Fafnir Bearing Co.**, New Britain, Conn.

For more data circle MD-65, Page 223

Small Speed Reducer

Series 11 Bantam speed reducer has two parallel gear trains which are spring loaded against each other. Thus, backlash is taken up continuously whether reducer is running or not. The torsion spring is wound to provide an anti-back-

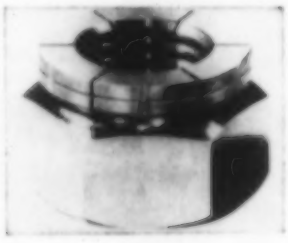


lash torque of 2 lb-in. in either direction. Where maximum output torque is not needed, spring torsion may be reduced to permit lower input torques. Gears are hobbed, 48 pitch, and hardened for smooth operation and long life. Antifriction bearings are used throughout. Reducers are available in 600 standard ratios. Made by **Metron Instrument Co.**, 432 Lincoln St., Denver 3, Colo.

For more data circle MD-66, Page 223

Locknut

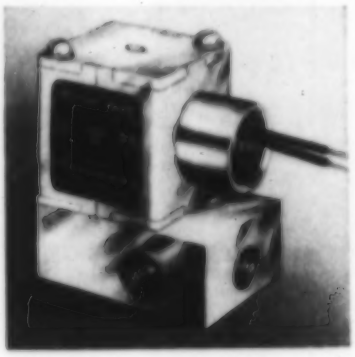
Designed to withstand high tightening torques, heavy vibration and stresses, new Flexloc locknut is made with eight threads



per inch. Helix of the thread can secure high pressure without excessive wrenching. All-metal, one-piece design permits use as stop nut as well as a locknut. Diameters range from 1 to 2 in. in increments of ⅛-in. The alloy steel fastener can be plated with zinc or cadmium. Slotted top with six equal closed-in segments assures a locking grip on bolt; nut will not gall and withstands high temperatures. Made by **Standard Pressed Steel Co.**, Stewart Ave., Jenkintown, Pa.

For more data circle MD-67, Page 223

Four-Way Valve



Four-way solenoid valve is positive acting even under conditions of heavy contamination. Incorporating the Floating Seal design, it has one sealing surface that is self-cleaning. Constant wiping action prevents contaminants from interfering with valve's normal operation. For use with air, hydraulic oils and other common media, the valve has a single coil and fewer parts than conventional valves. It is available with conduit or standard fittings, ¼-in. NPT pipe connections, for 115 v ac continuous duty. Power con-

A "mechanical brain" safety checks lubrication!

ALEMITE Accumeter®

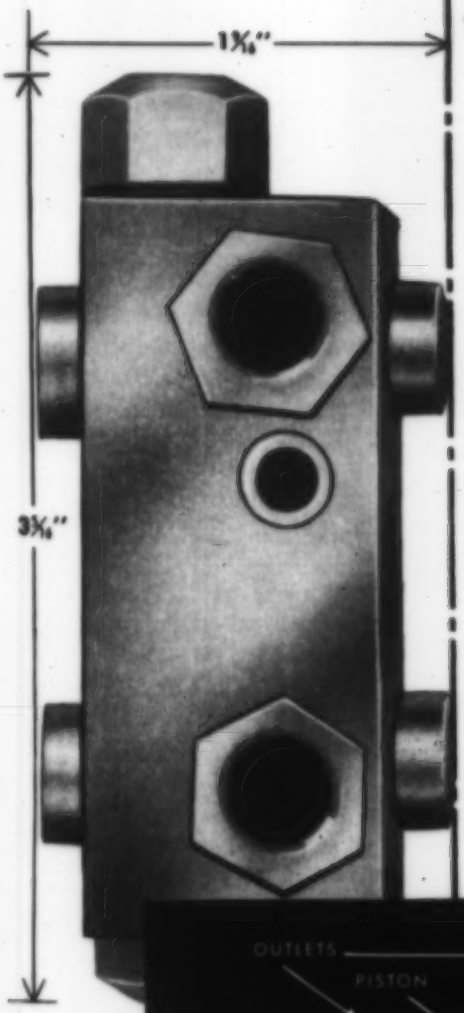
Assures automatic, foolproof lubrication under toughest conditions, on heaviest machines, indoors or out!

Imagine bearings operating under the very *worst* job conditions—in dust, rain, fumes, grit—even completely immersed. Now imagine what happens if you depend on ordinary manual methods of lubrication. Costly? Sure. Dependable? Hardly, may even be impossible.

That's the spot for Alemite Accumeter, the system with a control valve far more dependable than any man. The system that completely assures regular, proper lubrication, even under toughest conditions. Delivers the *exact* amount of lubricant where needed at the right time, *while the machine is in operation!*

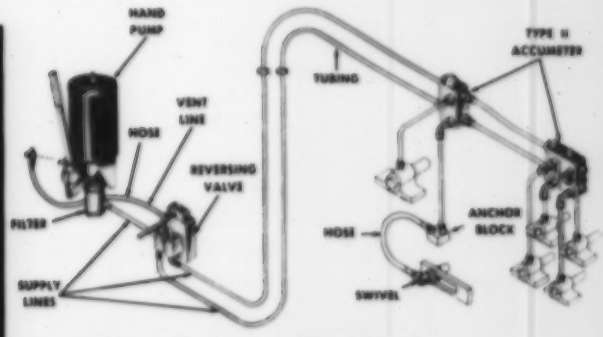
Costs, down-time, maintenance are all slashed by Accumeter—and output soars. That's why more than 95% of all major plants buying machine tools specify centralized lubrication!

And Alemite Accumeter Systems are easy to design into any machine. There is a system to solve any machine lubrication problem or combination of problems. See for yourself the tremendous operating advantages you offer when you specify automatic Alemite Accumeter.



Type II Accumeter Valves

Each serves two bearings. In four sizes delivering from .010 to .500 cubic inch of lubricant. Adjustable. Fully hydraulic—no springs. Completely sealed system serves up to 600 bearings. Manual or power operation.



Offers all these advantages!

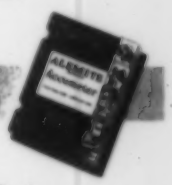
- **Eliminates shut-down time for lubrication. Adds productive time to machine output.**
- **Seals completely against dirt, grit, fumes, water all the way from "barrel to bearing."**
- **Prevents bearing troubles due to neglect or wrong lubricant.**
- **Services all bearings—including those inaccessible or dangerous—in one operation.**
- **Avoids work spoilage and bearing repairs due to over-lubrication.**

Factory tested—field proved

Exhaustive, in-the-field tests show no appreciable variation in the amount of lubricant discharged after 73,312 lubrication cycles. Equal to 122 years of twice-a-day service!

ALEMITE

REG. U. S. PAT. OFF.



FREE! ALEMITE ACCUMETER CATALOGUE

ALEMITE, Dept. R-35
1850 Diversey Parkway, Chicago 14, Illinois

A PRODUCT OF SW STEWART-WARNER

Name .....

Company .....

Address .....

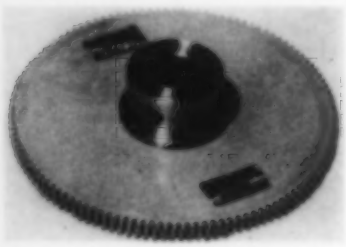
City ..... Zone ..... State .....

sumption is 10 w. Made by **Valcor Engineering Corp.**, Carnegie Ave., Kenilworth, N. J.

For more data circle MD-68, Page 223

Gear Assembly

Stainless steel springs take up the backlash in this precision gear assembly which is designed for applications requiring zero backlash. Two anodized aluminum gears can be rotated in opposite directions until they engage firmly with the mating gear. Regardless of direction of rotation of this gear, backlash does not occur. Assemblies are designed to use three standard adapters for ⅛, 3/16

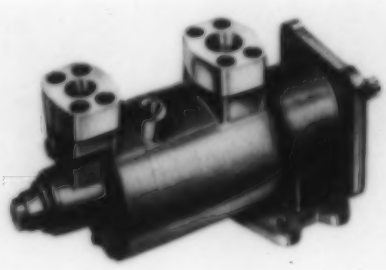


and ¼-in. shafts. They have stainless steel setscrews for holding and sub-drill holes for fixed pinning as desired. Gears are available from stock in 48, 64, 72 and 96 pitch, 20-deg pressure angle; 14½-deg pressure angle is available. A wide selection of number of teeth is offered. Made by **PIC Design Corp.**, 160 Atlantic Ave., Lynbrook, L. I., N. Y.

For more data circle MD-69, Page 223

Variable Delivery Pumps

Wide range of hydraulic fluids, including synthetics and nonflammables, can be handled by PV-600 series variable delivery pumps. Designed for pressures to 5000 psi, pumps are available with handwheel control for manual adjustment of output, or pressure-compensated control for automatic regulation of pressure and flow. Delivery is 3.0 gpm at 1200 rpm and 4.0 gpm at maximum continuous speed of 2000 rpm at full rated pressure, equal to 11 hydraulic horsepower. Axial piston type pumps have nine equally spaced pistons in a fixed cylinder block. Self-priming, self-lubricating units are not affected by variations in inlet pressure or fluid temperature. Drive can be direct through solid or flexible couplings or by gear or pulley. Direction of rotation is optional. Made by **New York Air Brake Co.**, Dudco Div., 1700 E. Nine Mile Rd., Hazel Park, Mich.



For more data circle MD-70, Page 223

Overload Protection Clutches

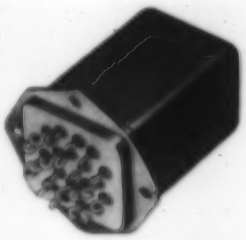
High friction, wearproof friction disks and adjusting nut locking arrangement are improvements incorporated in line of Torque Limiters. The machinery drive overload protection devices are slip type friction clutch units upon which such drive components as standard type A plain-plate roller-chain sprockets, special V-belt pulleys or gears can

be mounted. When an overload is imposed on a machinery drive, the sprocket or related drive component breaks away from the clutch disks and slips at from one-half to one-third the torque setting until the motor is shut off and the overload condition corrected. No resetting is required. Friction disks do not absorb oil or moisture. Torque Limiters are made in 11 standard models with maximum torque capacities from 20 to 620 ft-lb. For mounting on shafts with ½ to 2½ in. diameter, they are available in sizes from 2 to 3⅞ in. Made by **Morse Chain Co.**, 7601 Central Ave., Detroit 10, Mich.

For more data circle MD-71, Page 223

Subminiature Relay

All contacts of the series 2055 subminiature relay are rated at 5 amp, 24 to 30 v, dc resistive load.



The six-pole, double-throw, hermetically sealed unit withstands 100 *g* shock and 10 *g* vibration, from 75 to 2000 cycles per second, in all mounting planes. Fine silver contacts assure extremely low contact resistance. High contact pressure is maintained in both energized and de-energized positions. Made by **Guardian Electric Mfg. Co.**, 1621 W. Walnut St., Chicago 12, Ill.

For more data circle MD-72, Page 223

Solenoid Valves

Brass, type F, and stainless steel, type G, direct-lift solenoid valves for general service are made in ⅛ and ¼-in. pipe sizes, with ports from 1/16 to ¼-in. Maximum operating pressures are 1000 psi for air and gas; 600 psi for water; 500 psi for oil and 200 psi for steam. Valves have renewable metal seats, and coils are interchangeable with those of other Gould valves. Solenoid coils are

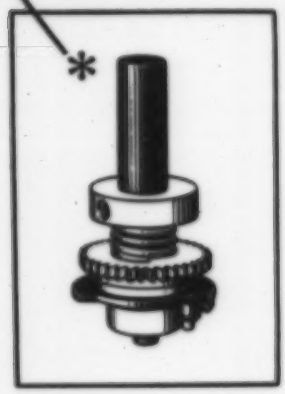
Design Simplicity —
Key to Trouble-Free Operation

1. Easy setting on full-view scale.
2. Quality switches rigidly mounted.
3. Housing encloses, protects mechanism.
4. Powerful Cramer synchronous motor.
5. Bakelite base ruggedly constructed.

CRAMER

type 230
INTERVAL TIMER

. . . manually set to control the opening of one circuit and closing of another for a selected time interval.



A "look inside" the Type 230 Interval Timer illustrates how design simplicity and precision workmanship contribute to trouble-free performance.

For example, the friction clutch assembly shown at left has few operating parts, yet is highly efficient. All friction forces are held internally within the clutch. No force is exerted either up or down to cause unnecessary load on the motor. The clutch essentially "floats" in the timer, thus minimizing wear, increasing reliability, and contributing to long motor and timer life.

Every component of every Cramer timer has been designed for simplicity, accuracy and operating dependability. For the complete story on interval timers, write for Bulletin PB-210.

Cramer TIMING DEVICES

SPECIALISTS IN TIME CONTROL

The R. W. CRAMER CO., Inc.

BOX 6, CENTERBROOK, CONNECTICUT

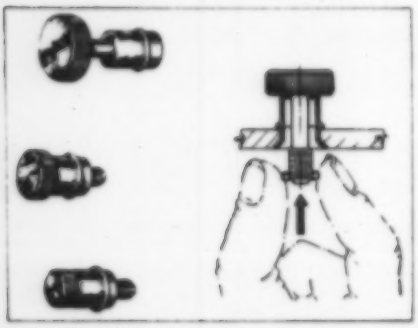
7CR88

waterproof, hermetically sealed in a molded thermoplastic casing. Maximum operating temperature is 250 F. Optionally available are silicone coils for high-temperature applications, as well as leakproof and Guidon seating assemblies. Made by **J. D. Gould Co.**, 730 E. Washington St., Indianapolis 2, Ind.

For more data circle MD-73, Page 223

Retractable Screw Fasteners

Attachment and removal of panels, plates and drawers is facilitated by quick-release retractable screw fasteners. Requiring no special tools, assembly of these fasteners is fast and simple. Components are stand-off, screw and vinyl plastic O-ring. Stand-off is

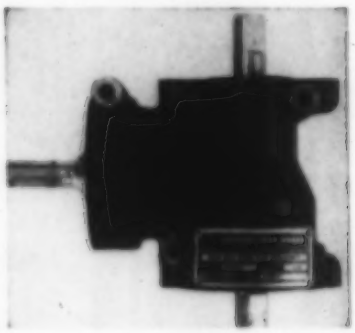


flanged into door; screw assembly is inserted and retained by O-ring; and screw is then engaged to frame, permitting easy removal of panel while fastener remains locked in door. Floating action of screw permits ample play to compensate for misalignment. Brass screw and stand-off are nickel plated. Three head sizes, all with parallel knurl, and three screw sizes are available. Slotted heads, stainless steel screws and extra long screws also can be obtained. Made by **South Chester Corp.**, Southco Div., Third St. and N. Governor Printz Blvd., Lester, Pa.

For more data circle MD-74, Page 223

T-Boxes, Angle Drives

New series of high-precision, high-torque T-boxes and angle drives includes model 1799E2 T-box, which is rated at 1000 lb-in. torque at 20 rpm and 400 lb-in. torque at 40 rpm. Maximum static torque is 1200 lb in., with ultimate static torque 1800 lb-in., 1400 rpm no-load speed. Unit is

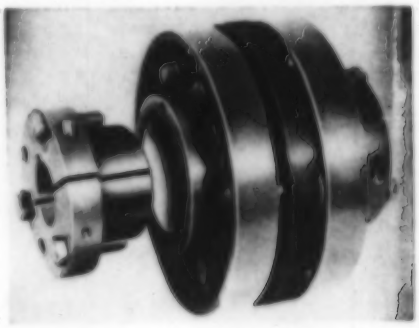


permanently lubricated and has been life cycled under various load tests up to 12 million revolutions. Made by **Western Gear Works**, Aviation and Electro Products, P. O. Box 192, Lynwood, Calif.

For more data circle MD-75, Page 223

Flexible Coupling

Line of heavy-duty flexible couplings, employing a knob-disk flexible medium, is equipped with one-piece, split-taper bushings for quick mounting. In addition to affording easy shaft handling, bushing permits coupling to be used to connect shafts of different sizes. It also simplifies close-coupled mounting, since bushing can be locked on shaft by means of a cross bolt, and coupling then drawn up by means of jack screws. Couplings are offered in eight sizes based on ratings up to 75 hp at 100 rpm. Flexible member is heavy, rubber impregnated fabric disk which has molded-in semi-spherical rubber knobs. This con-

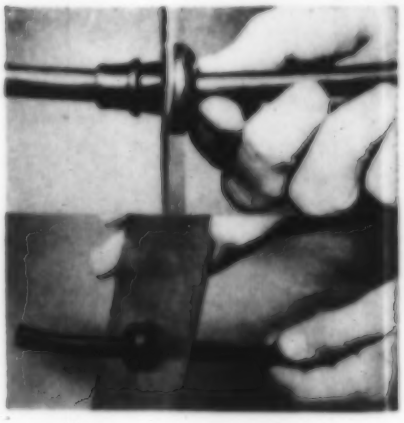


struction enables coupling to absorb shock, vibration, backlash and misalignment. When flanges are bolted to disk, knobs compress, increasing shock-absorbing energies of entire disk. Couplings are available with bushings in 1/16-in. shaft diameter increments over entire bore range. Made by **Climax Metal Products Co.**, 863 E. 140th St., Cleveland 10, O.

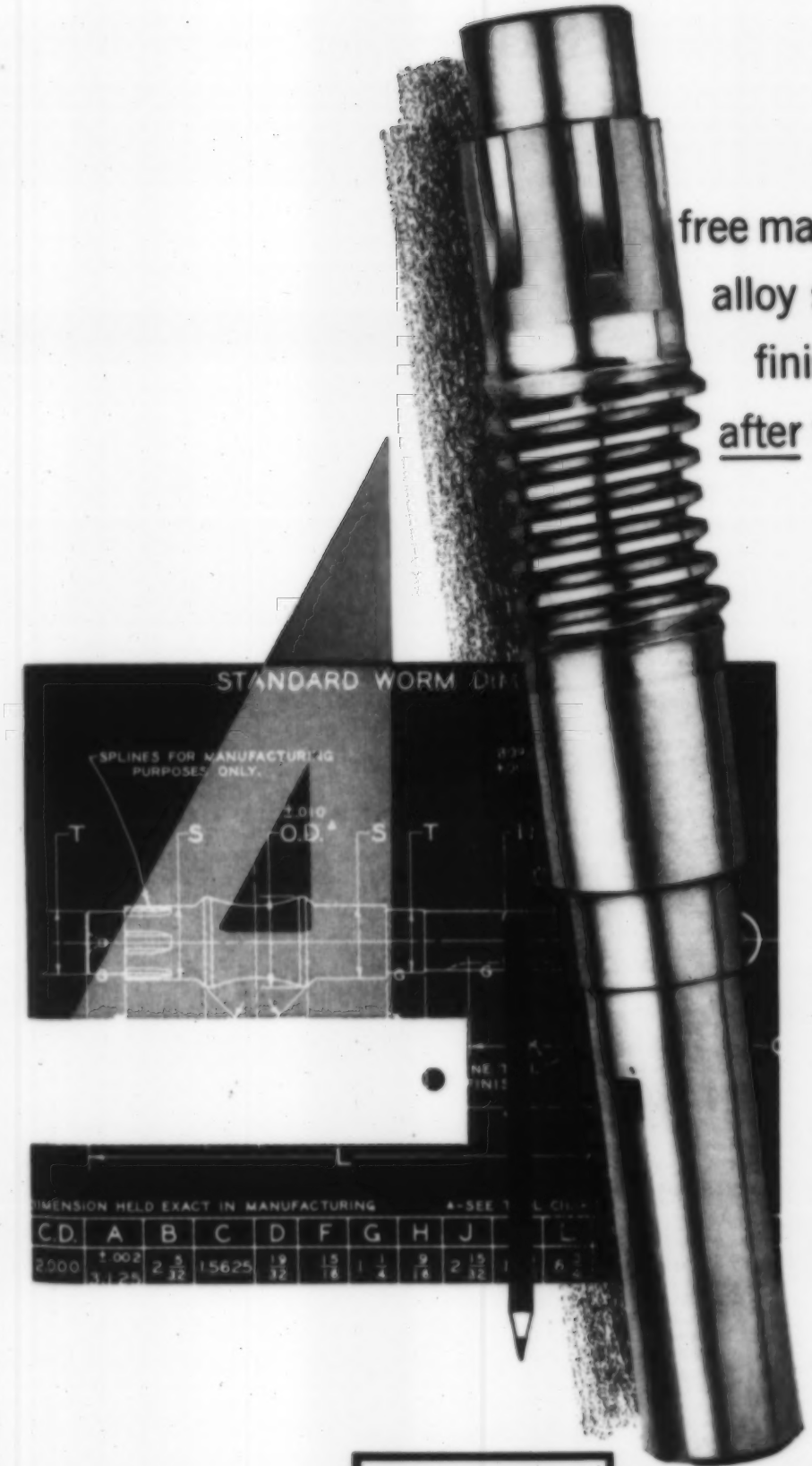
For more data circle MD-76, Page 223

Self-Sealing Grommet

Functioning as pressure seal, parts positioner, vibration dampener or insulator, the Moorhead Roll-Lock grommet is easy to install. It is inserted in hole; cable, wire or tubing is inserted through its hollow center for the desired length plus a few inches; and then



wire or tube is pulled in reverse direction to cause tapered end to roll inward upon itself. This locks grommet in place and forms a seal against entry of water, air, dust, moisture and chemicals. Grommet can also serve as electrical insulator. Reverse push on wire or tubing unlocks grommet


STANDARD WORM DI
SPLINES FOR MANUFACTURING PURPOSES ONLY.
O.D.
DIMENSION HELD EXACT IN MANUFACTURING
C.D. A B C D F G H J
2.000 1.5625

free machining **MAX-EL** alloy steel worm finish machined after full heat treatment...

This double enveloping worm of Crucible MAX-EL® 3½ alloy steel, made by Cone Drive Gears, Division of Michigan Tool Company, was completely machined *after full heat treatment.*

As our customer writes: "This requires an extremely free-cutting material in order to secure desired accuracy, and we have used MAX-EL quite successfully, due to its free machinability in the heat-treated state (Rockwell C 35-38)."

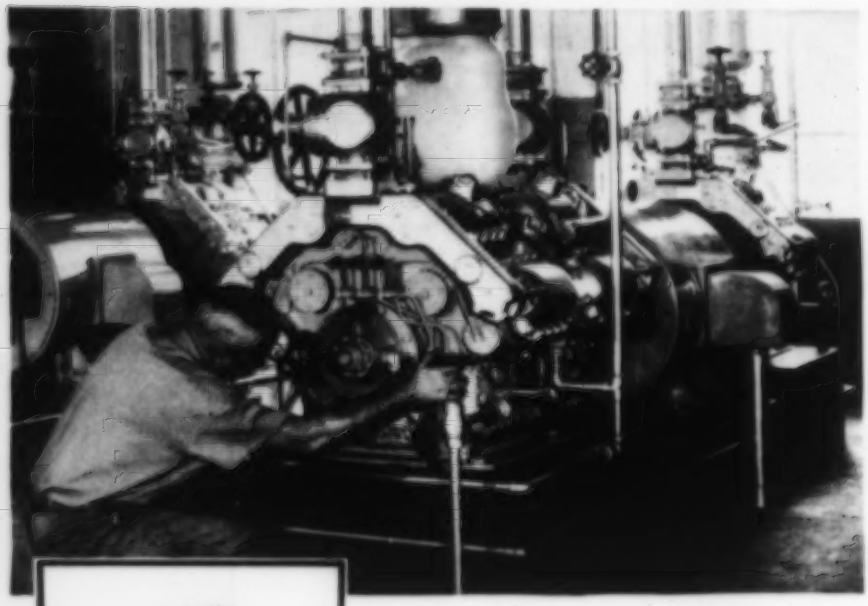
But try MAX-EL for yourself. You'll find that its free machining qualities, freedom from distortion, deep hardening characteristics, and the longer tool life you will get from its use, will help your production line run smoother. For further information, and *fast* delivery of MAX-EL – *call Crucible.*

CRUCIBLE first name in special purpose steels

54 years of Fine steelmaking **ALLOY STEELS**

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

HOW TO PICK THE PUMP TO DO THE BEST JOB FOR YOU IN Pressure Lubrication



MODEL L—Mechanically sealed pumps. Ask for Catalog 101

MODEL C—General purpose pumps. Ask for Catalog 102

MODEL R—Automatic reversing pumps. Ask for Catalog 105

MODELS S and SA—Stripped pumps. Ask for Catalog 106

TUTHILL Simplifies Pump Selection for your Application

As the leader in pumps for pressure lubrication service, Tuthill offers a complete line of rotary, internal-gear, positive displacement pumps to take care of any possible application. The Tuthill line includes models for standard requirements, automatic reversing types and stripped pumps for built-in applications. To make it easy for you to select the pump best-suited to your needs, Tuthill catalogs are available covering each series of pumps, as listed below.

Write for the Catalog that fits your application

Ask for Catalog 101 on Model L series if your needs call for ½ to 6 g.p.m. at pressures to 600 p.s.i.

Ask for Catalog 102 on Model C series if your needs call for 2 to 200 g.p.m. at pressures to 100 p.s.i.

—Ask for Catalog 105 on Model R (automatic reversing) series—from ¾ to 200 g.p.m. at pressures to 400 p.s.i.

Ask for Catalog 106 on Models S and SA stripped pumps for built-in applications —from ½ to 200 g.p.m. at pressures to 200 p.s.i.

TUTHILL PUMPS FOR THE PURPOSE

TUTHILL PUMP COMPANY

Dependable Rotary Pumps since 1927

939 East 95th Street, Chicago 19, Illinois

Canadian Affiliate—Ingersoll Machine & Tool Co., Ltd. Ingersoll, Ontario, Canada

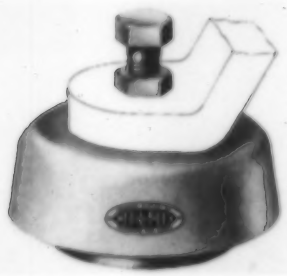
New Parts

for easy removal. On smooth tubing, seal formed will withstand hydrostatic pressures to 225 psi. By using simple installation tool, grommets are applicable without a pass-through or companion wire or tube. Grommets can be molded from standard or special or synthetic rubber compounds in a wide range of sizes. Made by **Stalwart Rubber Co.**, 180 Northfield Rd., Bedford, O.

For more data circle MD-77, Page 223

Adjustable Machinery Mount

All metal Adjust-O-Mount model W139, one of a new line of Met-L-Flex mountings, has a simple, built-in leveling device. Without the need for special tools, the device provides for mounting, leveling and aligning a machine in minutes' time. Designed to meet high



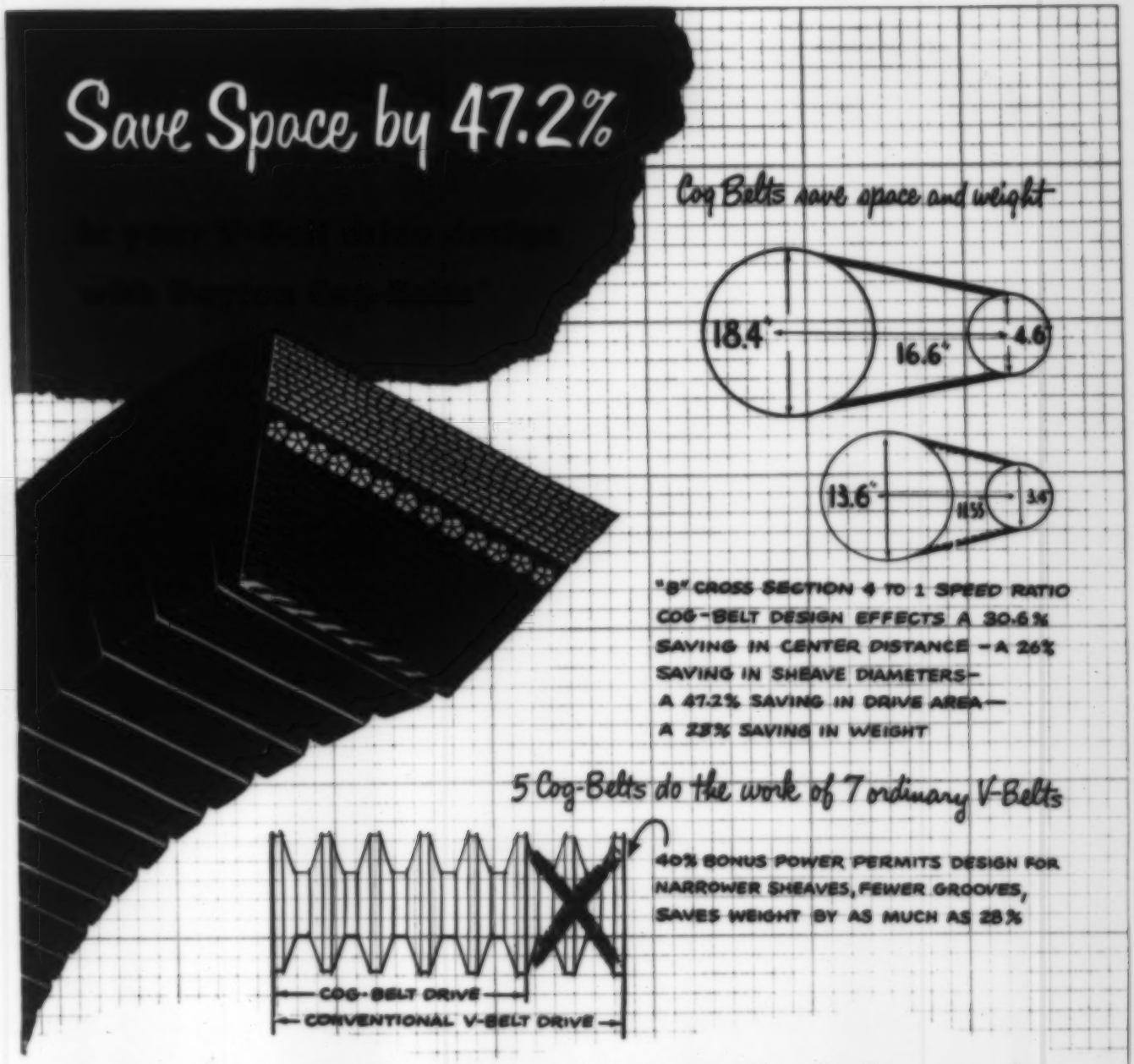
standards of shock and vibration control, the mount offers good stability to practically all types of machine tools and equipment. Exposure to oil, water, solvents, dust or extreme temperatures will not affect it. Made by **Robinson Aviation Inc.**, Industrial Div., Teterboro Air Terminal, Teterboro N. J.

For more data circle MD-78, Page 223

Relays and Contactors

Mechanically latched contactors and relays are designed to maintain continuity of sequencing in event of power interruptions. Units eliminate continued energization of the coil and resultant coil hum. After main device coil is momentarily energized to seal contacts, mechanical latch locks contacts in position until latch

Save Space by 47.2%


Cog Belts save space and weight
18.4"
16.6"
4.6"
13.6"
11.55
3.4"
"B" CROSS SECTION 4 TO 1 SPEED RATIO COG-BELT DESIGN EFFECTS A 30.6% SAVING IN CENTER DISTANCE – A 26% SAVING IN SHEAVE DIAMETERS– A 47.2% SAVING IN DRIVE AREA— A 28% SAVING IN WEIGHT
5 Cog-Belts do the work of 7 ordinary V-Belts
40% BONUS POWER PERMITS DESIGN FOR NARROWER SHEAVES, FEWER GROOVES, SAVES WEIGHT BY AS MUCH AS 28%
COG-BELT DRIVE
CONVENTIONAL V-BELT DRIVE

If your problem is to design a V-Belt drive to deliver the *full* power of your product in a limited operating space, yet still get consistent efficiency and long, economical service, you can do it with Dayton Cog-Belts.

You can use smaller sheaves with fewer grooves and shorter and fewer belts. For example, 5 Dayton Cog-Belts do the work of 7 ordinary V-Belts. Besides saving space, you reduce weight and costs.

They offer greater grip, strength, flexibility and heat and static dissipation for power drives characterized by high speeds. They're the perfect answer where short centers, small sheave diameters, continuous operation and excessive external heat, dirt, oil or grease are factors.

For prompt attention, write to: Dayton Rubber Company, Industrial Division, Dept. 672, Dayton 1, Ohio.

Check These exclusive Design Advantages:

1—The Tension Section flexes easily, giving longer life.

2—The Load Carrying Section has maximum stretch-proof strength.

3—The Compression Section has unequalled cross-wise rigidity.

4—Preformed, integral Cogs flex uniformly for full grip.

5—Smooth, die-cut sides assure positive grip, *full* power.

*T.M.

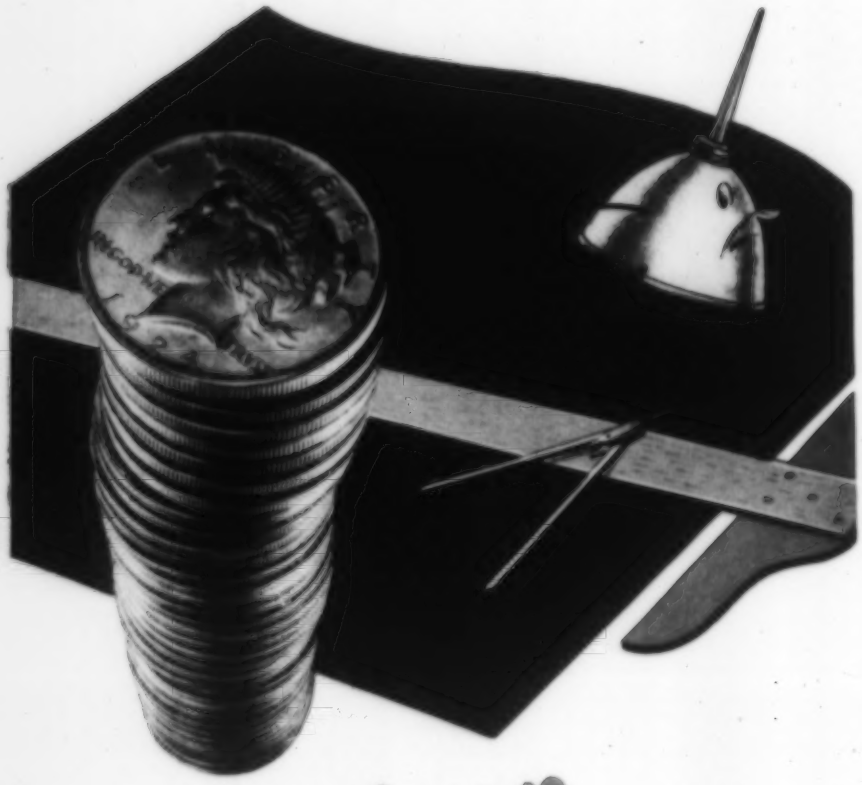
© D.R. 1955

1905 · 1955

Dayton Rubber

50 YEARS OF PROGRESS

Dayton Rubber Company, Industrial Division, Dayton 1, Ohio • *World's Largest Manufacturer of V-Belts*



Profit Grows When The Oil Can Goes!

BIJUR

Automatic Lubrication

When you design a machine to include Bijur Automatic Lubrication as an integral component, the user profits many ways. Costly hand oiling is eliminated. Repair bills are substantially reduced. Productive capacity is increased because machines are lubricated while in operation; downtime is reduced. Every bearing receives the right quantity of oil at the right time. There are no starved or flooded bearings. In your customer's plant, safety is increased; fire risk is lessened; personnel injuries are avoided. All this adds up to greater sales appeal for your machines.

For more than a quarter of a century, machine manufacturers have looked to Bijur as the accepted standard of automatic lubrication. Well over a million Bijur Systems have already been installed. Let Bijur design a custom-engineered lubrication system for you, to fit machines now in production or in the planning stage.

Literature and engineering data are yours for the asking.

O-1

BIJUR

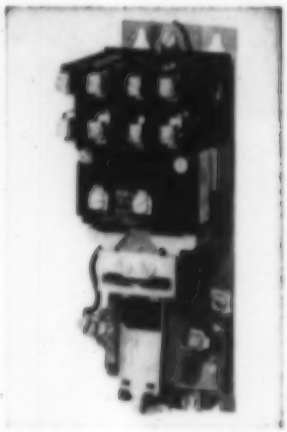
LUBRICATING CORPORATION

Rochelle Park, New Jersey

Pioneers in Automatic Lubrication

New Parts

coil is energized. When power is restored after failure, sequenced operations resume at point in cycle where they were cut off. Contactors are available in NEMA sizes 00, 0 and 1, open and enclosed, and in 1, 2, 3 and 4 poles. The multipole relays are available



in 10-amp, 600-v maximum ratings, open and enclosed, and with 2, 3, 4, 6 and 8 poles, in any combination of normally open and/or normally closed positions. Made by **General Electric Co.**, Schenectady 5, N. Y.

For more data circle MD-70, Page 223

Lubrication Unit

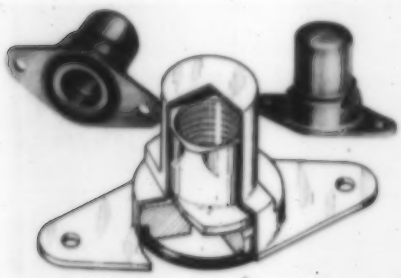
Model 33AB-4 oil fog type lubricator has twin lubricator heads which may be used simultaneously or individually, depending on specific requirements. Fog generated can be carried long distances with a minimum of precipitation in the lines and can be distributed uniformly to multiple bearing lubrication points having a total bearing area of 1000 sq in. Automatic controls provide warn-

ing signals or other safeguards against depletion of oil supply, failure of air supply and excessive pressure in oil supply tank. Delivery of lubricant is co-ordinated to machine operation. Oil feed and oil supply are visible; incoming air is filtered and collected moisture automatically drained. Air requirements are variable depending upon oil fog output, maximum being 27 cfm at 60 psi operating pressure. Three 2-in. fog outlets are provided. Lubricator measures 27 x 12½ x 16½ in. and has 4½-gal capacity. Made by **C. A. Norgren Co.**, 3442 S. Elati St., Englewood, Colo.

For more data circle MD-80, Page 223

Self-Sealing Locknut

Type A2500 cap seal floating anchor nut provides a positive seal against leakage up to 50 psi on either side of the sealing element, regardless of vibration, strain or temperature changes. The all metal self-locking nut body is enclosed by a one-piece aluminum cap with a sealing ring in the base to prevent leakage under



the base of the nut and past the bolt threads. The nut body is designed with a floating action of 0.025-in. in all directions, to facilitate assembly and allow for misalignment of bolt holes. Parts meet AN-N-5 specifications for operation between −80 and 250 F; by proper selection of component materials, the operating temperature range can be extended above and below these limits. The seal is effective whether the bolt is installed or not, and it is not affected by repeated bolt installations. A full thread series is

(*Continued on Page* 242)

THE LOW COST BEARING THAT...

meets many needs

Cast Bronze Bunting Bearings can be supplied in many forms from the simplest to the most intricate. They offer many ways to cut the cost of both design and production without any sacrifice of performance or durability.

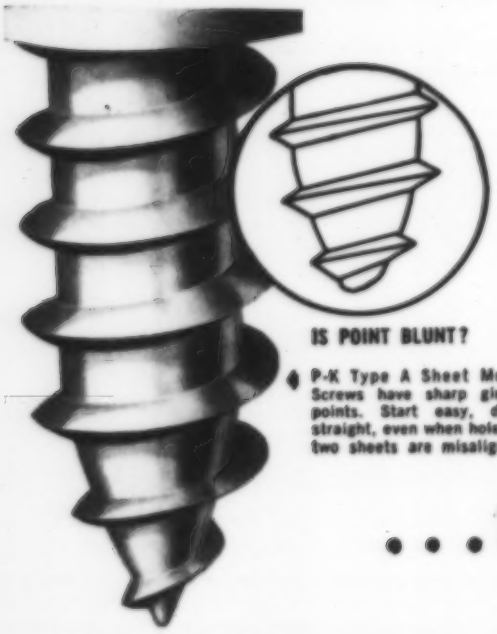
It may save you much expense and trouble to find out what Bunting Bronze Bearings can do for you. There is a Bunting engineer near you for consultation. Or write our Product Engineering Department at Toledo.

The Bunting Bearing offers ways to reduce the cost of a design and to employ designs that provide more economical production as well as lower initial cost.

Bunting.

BRONZE BEARINGS • BUSHINGS • PRECISION BRONZE BARS

THE BUNTING BRASS & BRONZE COMPANY, TOLEDO 1, OHIO
BRANCHES IN PRINCIPAL CITIES • DISTRIBUTORS EVERYWHERE


IS POINT BLUNT?
P-K Type A Sheet Metal Screws have sharp gimlet points. Start easy, drive straight, even when holes in two sheets are misaligned.

$0.15 .015 ... in assembly savings

the POINT makes the difference

A properly planned saving of 15 cents per unit can fade to 1½ cents — or nothing — on the assembly line . . . unless the screws you use have the good points that assure quick starting and straight driving.

Bad points are hard to detect in the package, but your cost sheets and customer complaints will soon show their effects — job slowdown, parts spoilage, hidden weakness.

That's why P-K quality standards have been set so high — to make sure you get P-K Self-tapping Screws that are not only *pointed for savings*, but headed, threaded, and heat-treated with one purpose, to keep your assembly lines trouble-free.

Start making *planned* assembly savings pay off . . . talk to a P-K Assembly Engineer. Parker-Kalon Division, General American Transportation Corporation, 200 Varick St., New York 14.

DOUBLE LEAD THREADS?
P-K Type Z Self-tapping Screws have well defined taper. Screw stands erect in hole and double lead thread means quick, easy starting; forms secure mating threads.

PARKER-KALON

IN STOCK . . . see your nearby P-K Distributor . . .

HOW MANY FLUTES?

♦ P-K Type F Screws have five thread cutting flutes; easier to start, less torque to drive, cut clean threads all the way in.

per unit

P-K STANDARDS
make sure you get
SCREWS POINTED FOR SAVINGS

P-K design and quality standards protect you against the bad points shown and many others that will slow down assembly and cause parts damage. They don't "get by" P-K Inspectors — that's why *all* P-K Self-tapping Screws can be "Guaranteed First Quality."

IS PILOT TOO SHORT?

♦ Pilots of P-K Type U Drive Screws are proper size and length to permit screws to start straight, drive straight.

The First originated by P-K . . . and First today . . . the leading choice for fastening economy

SELF-TAPPING SCREWS

your local Supply and Service Specialist

STOW flexible shafting
ON THE JOB

pumping GAS on a tractor-trailer

STOW Flexible Shafts have effectively solved power take-off problems on both trucks and tractor-trailers. Large shafts, such as the 1¼" pictured above which transmits up to 10 H.P., have proven their ability on power take-off applications more efficiently and with more trouble-free service . . . **to operate pumps** for petroleum, milk and other liquids; **to operate conveyors** for grain, coal; **to operate compressors** on refrigeration trucks.

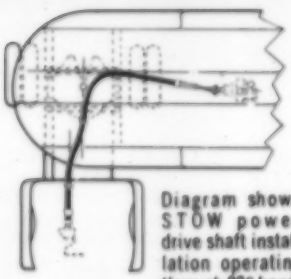


Diagram shows STOW power drive shaft installation operating through 90° bend.

Why not put Stow to work on your power drive problems? Stow Engineers are always at your service.

For complete engineering data and illustrations on STOW Flexible Shafting—Write today for FREE Bulletin 525.

Write today for Bulletin 542 and complete data on Power Take-Off drives.

STOW MANUFACTURING CO.
11 SHEAR ST., BINGHAMTON, N.Y.

New Parts

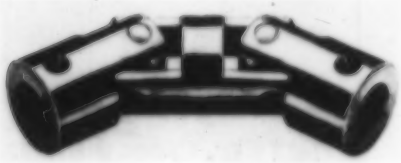
(*Continued from Page 239*)

available, including 10-32, ¼-28, 5/16-24, ⅜-24 and 7/16-20, all of which can be supplied in gang channel strips as well as individual nut plates. Made by **Elastic Stop Nut Corp. of America,** 2330 Vauxhall Rd., Union, N. J.

For more data circle MD-81, Page 223

Universal Joint and Coupling

Dual type universal joint for remote control use allows for lateral as well as angular displacement between connecting shafts. It operates effectively with included angles of 90 degrees or more and, as units are angularly phased, most cosine error is balanced out. Also available is a universal coupling, illustrated, that resembles a



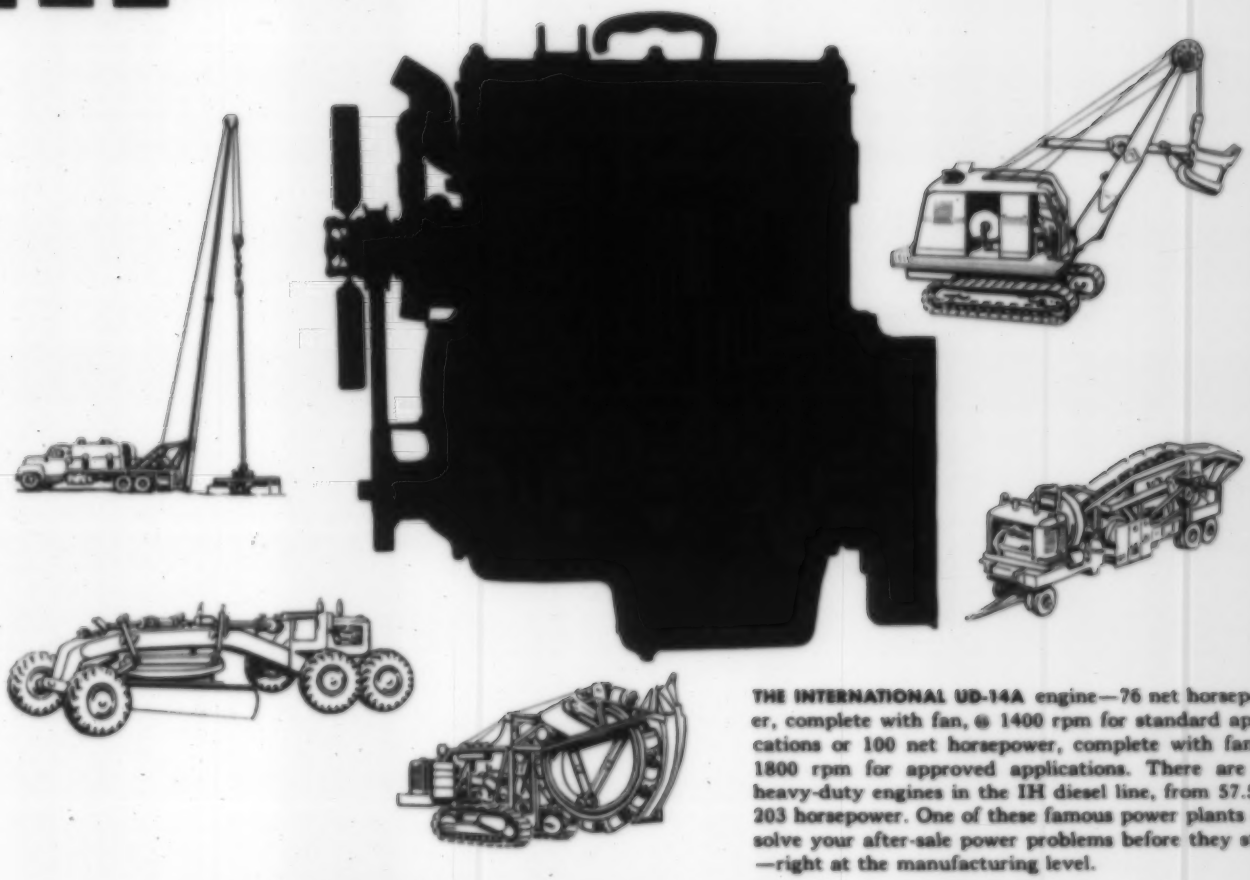
universal joint except that the block floats within the forks without pivot pins. This allows for slight lateral misalignment and moderate angular misalignment when connected to stable supported shafts. Both units are made in range of sizes including those for shafts of 3/16, ¼ and ⅜-in. diameter. Made by **Kupfrian Mfg. Corp.,** 382 State St., Binghamton, N. Y.

For more data circle MD-82, Page 223

Hydraulic Pressure Switch

Piston-operated hydraulic pressure switch incorporates a strain relief mechanism which allows the range spring to absorb the impact of a violent pressure surge. A Quad ring seal around the piston prevents oil leakage and eliminates the necessity for an oil return line. Types without the Quad ring are available for closer differentials. Switch has one normally open and one normally closed snap-action contact in a self-contained, arc-resistant Mela-

IH power protects your good name



THE INTERNATIONAL UD-14A engine—76 net horsepower, complete with fan, @ 1400 rpm for standard applications or 100 net horsepower, complete with fan, @ 1800 rpm for approved applications. There are six heavy-duty engines in the IH diesel line, from 57.5 to 203 horsepower. One of these famous power plants can solve your after-sale power problems before they start —right at the manufacturing level.

Specify INTERNATIONAL diesel engines—most popular 4-cycle power plants with the nation's power users

Power is as important as good product design and precision manufacturing in protecting your company's good name with customers.

That's why many of the nation's leading equipment manufacturers install INTERNATIONAL diesels in their products.

The six INTERNATIONAL diesels, as well as the 12 carbureted engines in this line, are made by a company with more than 50 years' experience in manufacturing heavy-duty power units. IH Distributors and power unit dealers provide unmatched after-sale service in the field with fully staffed and equipped shops, with full stocks of genuine IH parts backed by a network of IH Part Depots.

Our sales engineers will be glad to provide you detailed information and application assistance.

INTERNATIONAL HARVESTER COMPANY
Industrial Power Division, Melrose Park, Illinois

FREE—the new INTERNATIONAL Power Unit Catalog

Mail the coupon for your copy

INTERNATIONAL HARVESTER

INTERNATIONAL
INDUSTRIAL POWER

MAKES EVERY LOAD A PAYLOAD

International Harvester Company
Industrial Power Division
Melrose Park, Illinois

Gentlemen:

Please send a copy of the Power Unit Catalog to:

NAME_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

for **TOUGHNESS**
WEAR RESISTANCE
IMPACT

specify **AMSCO®**
MANGANESE STEEL

- nonmagnetic
- resists impact
- high strength
- work-hardens
- resists abrasion
- high ductility
- slow crack propagation
- low temperature toughness

Manganese steel actually *absorbs energy.* Impact work-hardens the surface of the metal to as high as 550 BHN, while below the surface it maintains its ductility. Roughest abrasion only polishes this versatile metal.

Another highly desirable feature is manganese steel's slow crack propagation rate. This is a built-in safety factor, allowing early discovery of impending failure so that remedial action can be taken before costly damage or breakdown occurs.

Amsco manganese steel, being an austenitic structure, remains tough at low temperatures, retaining a valuable safety factor even at cold −100°F.

All of its characteristics, including a complete discussion of its technical aspects and inherent design features are contained in the Amsco booklet, *Austenitic Manganese Steel.* It's free. Send for your copy today.

AMERICAN Brake Shoe COMPANY

AMERICAN MANGANESE STEEL DIVISION
Chicago Heights, Illinois

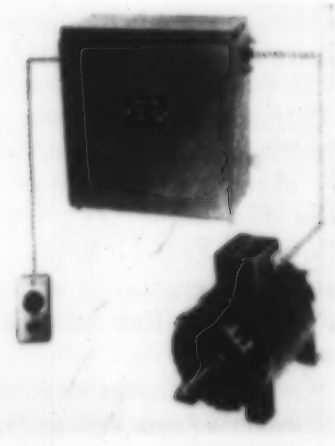
New Parts

mine case rated for ac or dc control circuits. Oiltight enclosure consists of a die-cast case and gasketed cover; explosion-resistant enclosures are also available. Switches are made with a range of 135 to 1000 psi or 400 to 3000 psi. They have close differentials and are easily adjusted in the field. Made by **Square D Co.**, 4041 N. Richards St., Milwaukee 12, Wis.

For more data circle MD-83, Page 223

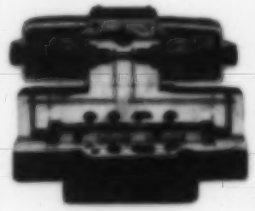
Adjustable-Speed Drive

First model in 200 series of electronic adjustable-speed drives employs a tachometer feedback signal to hold speed within the desired setting. Thus critical phasing circuits or adjustments are eliminated and better speed-load regulation is provided than is normally available from dc shunt motors when operated from variable-transformer controls. Both ¼ and ½-hp models are available with a choice of either 1800 or 3600 rpm as the base motor speed. Both models supply constant torque over a 30:1 speed range. A



NEW RACINE FLUID MOTOR

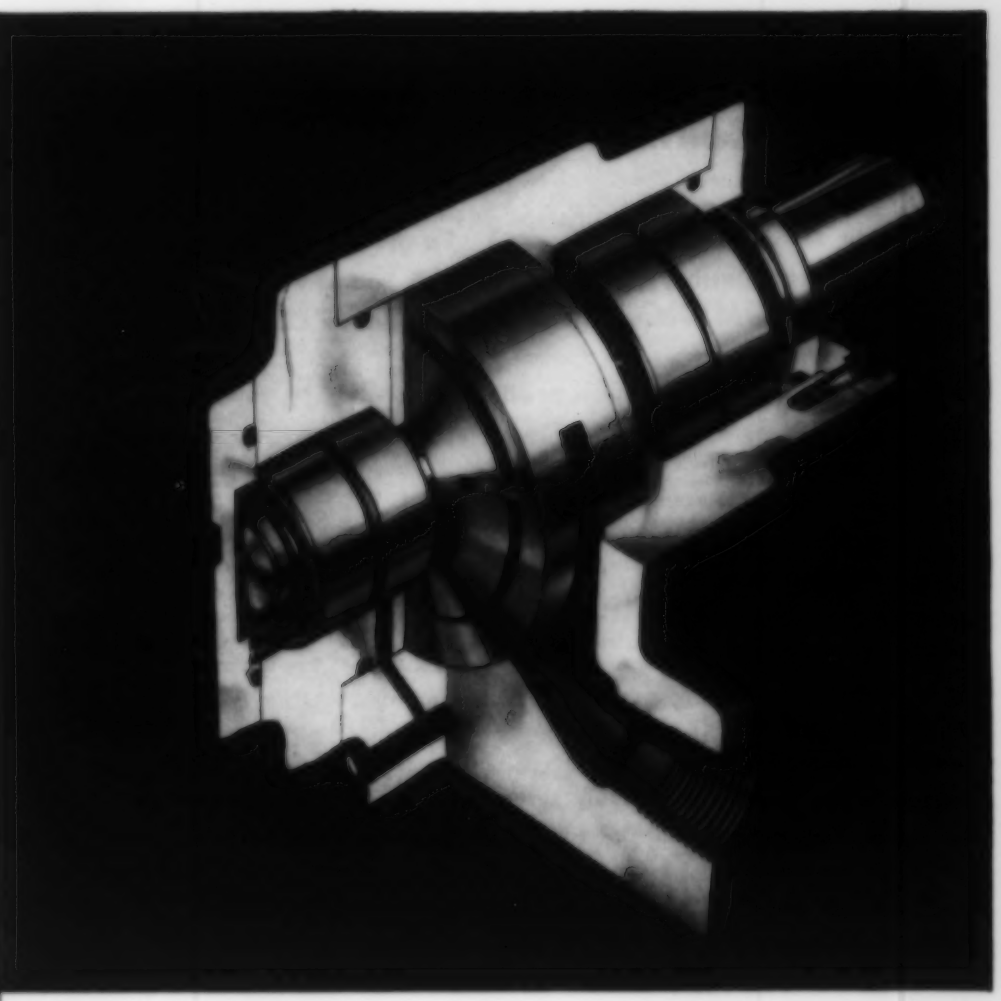
PROGRAMMED RESEARCH FOR PRODUCTION PROGRESS



Twin Solenoid Pilot Operated 4-Way Valve

Hydraulic Pressure Booster Pressures to 5000 p.s.i.

Hydraulic Power Unit Designed for your needs



A vane type constant displacement Fluid Motor that features simplicity and compactness of design. It is ruggedly built for continuous operation at pressures up to 1500 p.s.i. and Speeds of 50 to 3500 rpm.

Torque is constant at any degree of rotation. Heavy bearing construction will support overhung loads equal to full torque on a 6" diameter wheel plus a 100 pound external end thrust.

Write for prices and complete information on RACINE'S full line of Hydraulic Equipment. Address **RACINE HYDRAULICS & MACHINERY, INC.**, 2073 Albert Street, Racine, Wisconsin.

RACINE

"THEY WORK BETTER TOGETHER"

How about Malleable ?

Take Advantage of This Unusual Combination of Properties

Strength	Excellent Machinability
Toughness and Ductility	High Impact Resistance
Rust and Corrosion Resistance	Versatile Castability

• Malleable iron is a cast ferrous alloy heat-treated to provide a remarkable combination of properties. Malleable castings are both strong and tough—flow under excessive compressive and transverse loads, seldom fracture.

• Malleable castings machine easier than any other ferrous material of comparable strength and toughness.

• Malleable iron can be cast into intricate shapes close to final form, greatly reducing machining costs and eliminating complicated and costly assemblies.

• Malleable castings are highly resistant to atmospheric corrosion and are widely used for products used outdoors.

• Modern foundry methods and careful scientific casting control assure you of uniformly high quality castings for better products.

For complete specifications and tolerances for both standard and pearlitic malleable castings, write to the Malleable Founders' Society.

Malleable FOUNDERS' SOCIETY

1800 Union Commerce Building Cleveland 14, Ohio

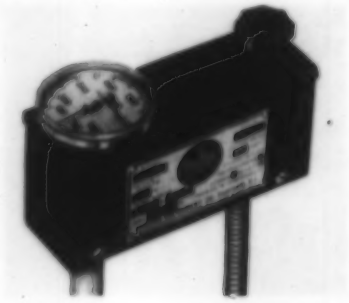
New Parts

concrete-like epoxy resin is used to fully encapsulate all resistors, capacitors, etc., within a single plug-in assembly. A screwdriver is the only tool needed to replace any part quickly. Rectifier cabinet, for either wall or bench mounting, is corrosion-resistant, chromate treated aluminum. Compact control head utilizes only low voltage circuits that can be installed at a point remote from either the rectifier cabinet or the motor. Made by **Servo-Tek Products Co.**, 1086 Goffle Rd., Hawthorne, N. J.

For more data circle MD-84, Page 223

Temperature Control

An independent dial thermometer is combined with a differential expansion type temperature control in the model LD-1S instrument. Several adjustable temperature ranges are offered from

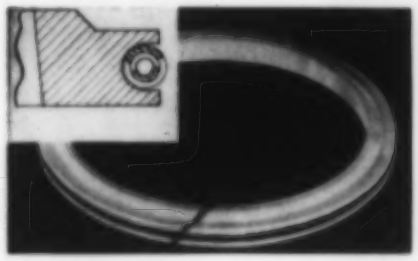


30 to 750 F and 0 to 400 C. Switch is rated at 15 amp, 125-250 v ac and operating differentials are ±1 to 4 F. Control is for local mounting and can have flange or threaded fittings. Tube is brass or stainless steel, ¾-in. OD by 14 in. Made by **Burling Instrument Co.**, 16 River Rd., Chatham, N. J.

For more data circle MD-85, Page 223

Piston Rod Scraper Rings

Use of low friction, nonscoring, durable and inert Kelon-T (Teflon) or Kelon-Y (Nylon) in S-11065 hydraulic piston rod scraper rings insures seal reliability and extends packing life by keeping dirt and other foreign matter away from O-ring seals. Rings are responsive to rod misalignments and

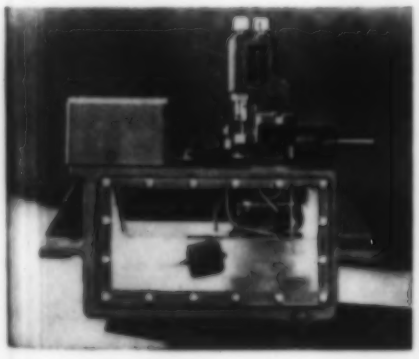


can be used at temperatures from −100 to 300 F. They are spring-loaded to maintain firm contact on the rod and are available in 72 sizes for rods from ½ to 13 in. OD. Made by **W. S. Shamban & Co.**, 11617 W. Jefferson Blvd., Culver City, Calif.

For more data circle MD-86, Page 225

Lubricators

Triple-service lubricators are designed for machines which require several methods of automatic lubrication from a single source. Illustrated unit is equipped with pneumatic controls and provides continuous, cyclic and jetting lubrication. Oil flow for all three services is provided by one gear pump which is driven by the machine through built-in reduction gearing. Valving and by-pass mechanisms within the pump provide



the means by which the three branches operate. The continuous branch operates at low pressure, controlled by a loading valve located between the by-pass and the main gear pump discharge. Oil is forced through tubing to the various points where it is distributed according to the individual needs of each bearing surface. The cyclic

(*Continued on Page 252*)

Here are 3 PROVEN ANSWERS to your timing problems

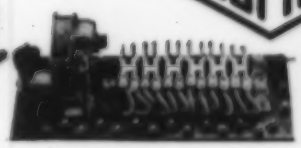
1

AEMCO

AUTOMATIC RESET TIMER

Opens or closes circuits for intervals of seconds or hours, recycling immediately or holding a circuit for a fixed interval before recycling. Stock models available with fixed or adjustable settings. In case of current interruption unit will recycle or hold position and recycle with return of current.

2



AEMCO

SEQUENCE TIMER

Engineered to meet requirements for the individual timing of a series of operations. All circuits are 15 amp., have positive quick make and break pure silver contacts. Friction clutch between cam shaft and motor gear train may be manually adjusted at any time desired. Automatic Sequence Timers may be supplied in SPST or SPDT . . . are carefully engineered to meet exacting specifications.

3

AEMCO

CYCLE MASTER

This low-cost Automatic Time Switch can be set for as many as 48 ON and OFF operations per revolution of the dial. Unit has a 15 minute minimum ON or OFF interval on 24 hour cycle unit . . . 7½ minute interval on 12 hour cycle models and as little as 37½ second intervals on 1 hour cycling models. All models will control up to 48 ON and OFF operations during cycle. Available with Sunday and holiday cutout in 10 or 20 amp. capacity . . . four to eight terminal panel.

AEMCO

ENGINEERED RELAYS

AEMCO also manufactures a complete line of quality relays . . . open and sealed type, midgets and miniatures . . . plug-in base or specialized mountings . . . an almost limitless variety of spring and coil combinations. AEMCO Relays exceed specs . . . *military or industrial!* Specialized units engineered and manufactured to meet particular requirements and specifications.

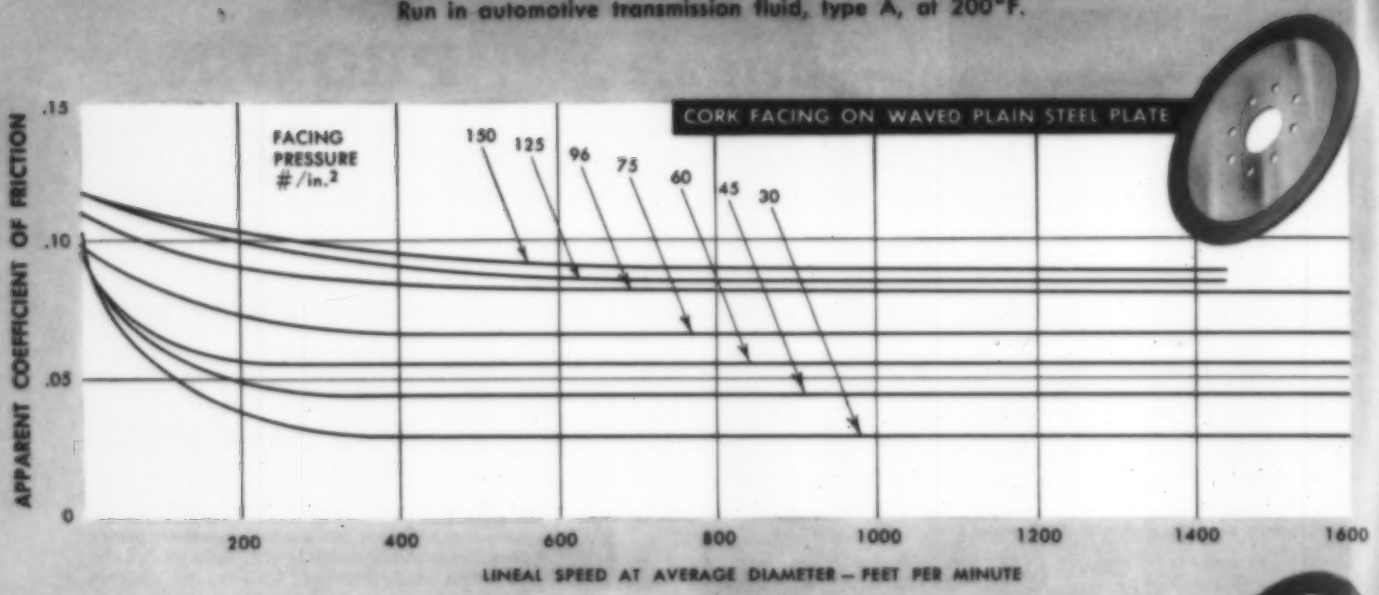
Why not write us today? The services of our skilled engineering staff are at your disposal.

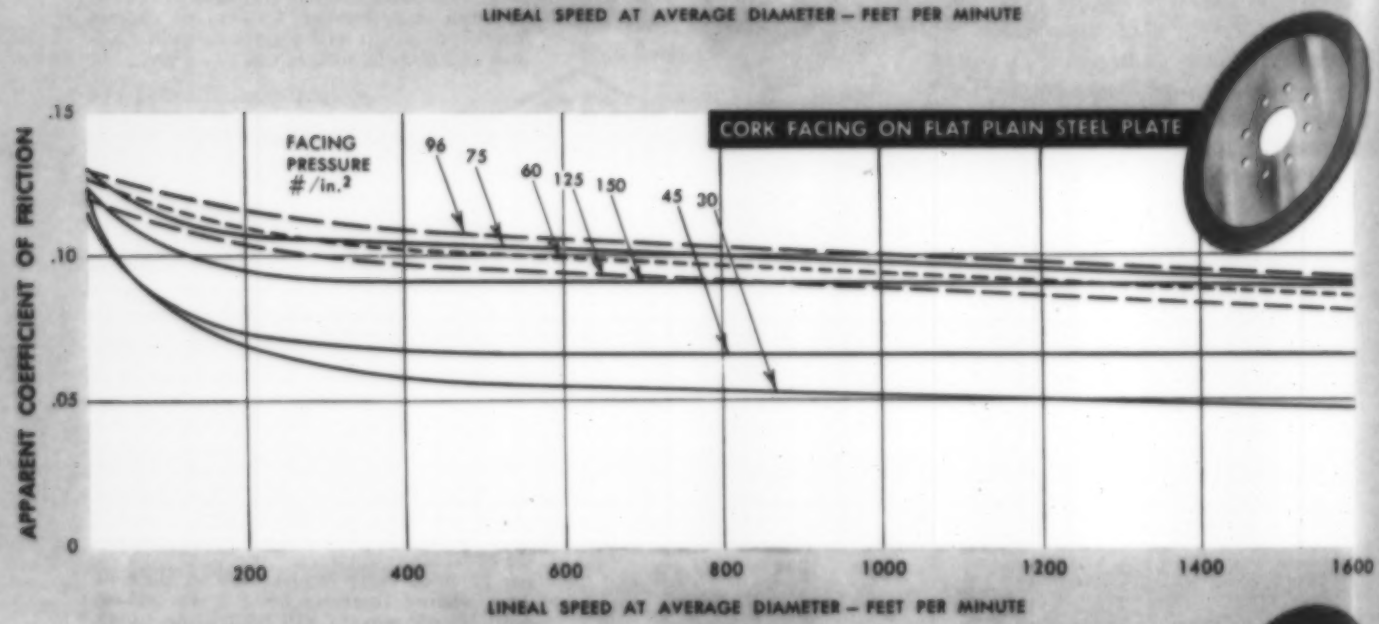
AEMCO Automatic Electric MFG. CO.

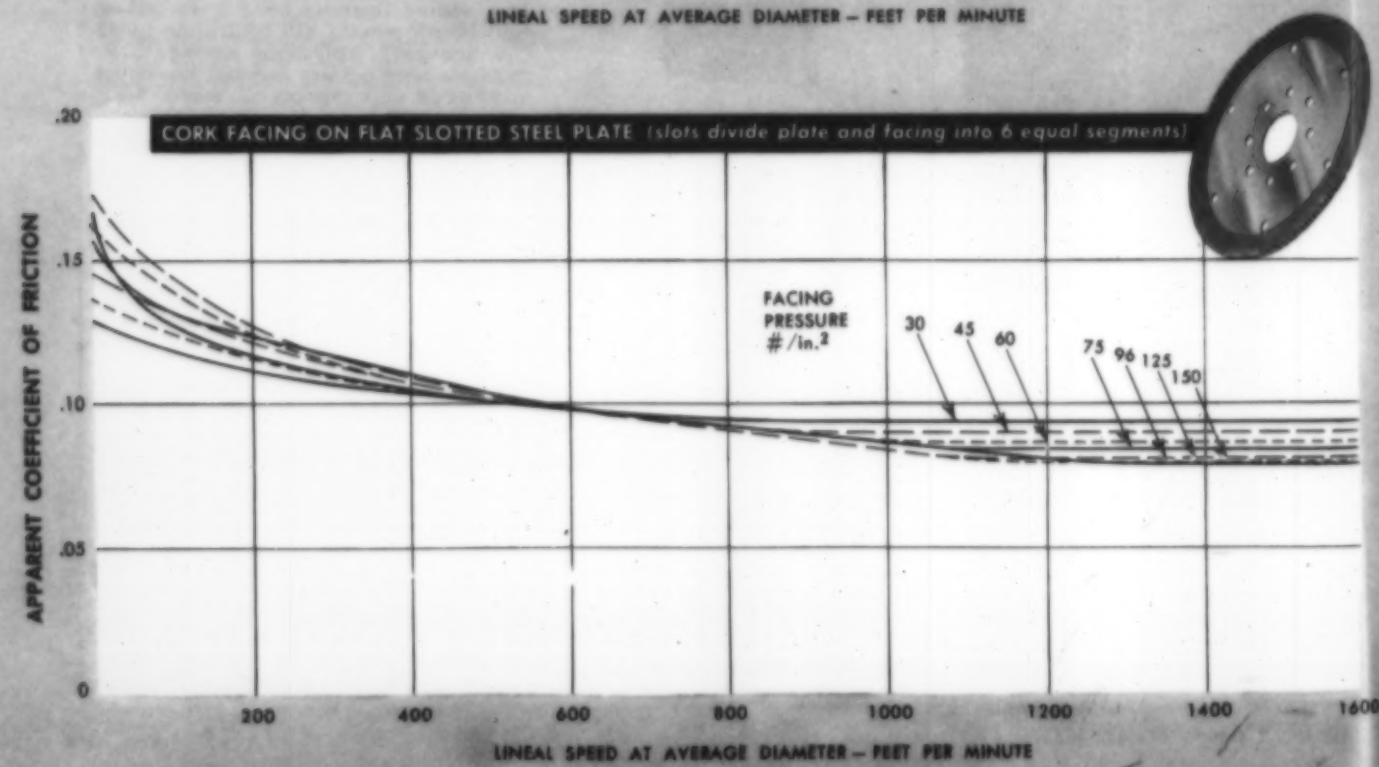
64 STATE STREET · MANKATO, MINN.

The Effect of Change in Plate Design

All test plates 6¼" I.D. x 7½" O.D. Same friction material on each plate.
Run in automotive transmission fluid, type A, at 200°F.







CORK CLUTCH FACINGS:

HOW ENGAGEMENT CHARACTERISTICS CAN BE MODIFIED BY SIMPLE CHANGES IN PLATE DESIGN

One of the unique advantages of cork-compound friction materials in wet clutches is that relatively simple changes in plate design allow the designer to control and manipulate the oil film and thus produce the desired engagement characteristics.

This versatility of cork facings stems from their unusually high coefficient of friction when immersed in oil, and from their inherent flexibility which permits the use of waved or coned plates.

The curves shown at the left show how typical changes in plate design may be used to modify wet clutch behavior. In each case, the plate size and friction material were identical. Yet the apparent coefficients of friction vary widely because of differences in plate design. For example:

On waved steel plates, (top chart) the cork facings apparently ride on the oil film at low pressures, like a Kingsbury Thrust Bearing. As pressure is increased, however, the waved plate flattens and better contact is made. When this happens, the apparent coefficient of friction rises until, at 150 psi., it equals the value at equivalent pressure shown for the other two plate designs.

On flat plain steel plates, (middle chart) the cork facings develop low friction values at low pressures. But full contact is generated much more quickly.

On flat slotted steel plates, (bottom chart) the cork facings produce apparent coefficients of friction that fall within a relatively narrow range. The slots apparently set up a "squeegee" action that tends to wipe away the separating oil film, even at low engagement pressures.

Controlling oil film controls engagement. In each of the examples given here, it is obvious that the oil film has a marked effect on the apparent coefficients of friction developed at pressures below those required to bring the facing into full contact with the opposing plate. However, as the charts demonstrate, simple changes in plate design enable the designer to control the oil film and thus produce the characteristics desired.

For more information on the design versatility of cork-compound friction materials, send for your free copy of our new 1955 booklet, "Armstrong Resilient Friction Materials." Write on your letterhead to Armstrong Cork Company, Industrial Division, 7203 Dean Street, Lancaster, Penna.

Armstrong FRICTION MATERIALS

. . used wherever performance counts

How fluid drives help make new General 320 Shovel a "hog" for yardage

Full-crowding power is designed into the new General Model 320 ¾-1 yard Shovel . . . for Osgood-General is offering a choice of Twin Disc *fluid drives.*

For operating conditions presenting extreme load demands, the new Model 320 is available with a Twin Disc 3-Stage Torque Converter, providing controlled torque multiplication.

For moderate load demands, the Twin Disc Fluid Power Take-Off is provided. With *either* drive, owners will have a "hog" for yardage . . . through cushioned power applied through fluid, eliminating mechanical connection. Work cycles are *faster,* productive output is *higher, without* engine lugging or cable-snapping. Add Twin Disc Friction Clutches as standard equipment on the Model 320's boom hoist, swing assembly, and for travel—and you have *engineered power linkage, with the right drives in the right places.*

Write Twin Disc today for Complete Line Bulletin No. 305.

Model 320 features Twin Disc Heavy-Duty Friction Clutches for swing and travel, boom hoist and lower, retraction, and power take-off.

Model CF Torque Converter (shown) on diesel-powered Model 320. Fluid Power Take-Off also available.

TWIN DISC

TWIN DISC

Friction Clutches and Fluid Drives

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

Branches or Sales Engineering Offices: Cleveland • Dallas • Detroit • Los Angeles • Newark • New Orleans • Seattle • Tulsa

New Parts

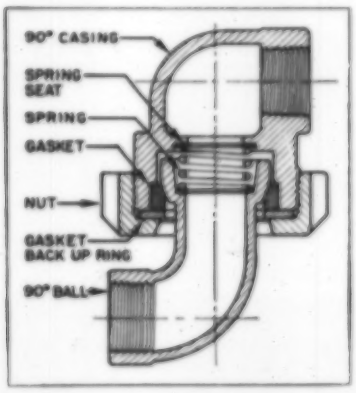
(*Continued from Page 249*)

branch operates at high pressure on a predetermined time schedule. A cam, driven by the internal reduction gearing, actuates a timing valve, and oil is forced into the proper tubing. Jetting is accomplished by operation of a piston valve in the pump which permits oil to discharge through ports to the jetting line. This valve is actuated by a pneumatic cylinder which is in turn operated through a solenoid air valve controlled either by a timer or a pushbutton on the machine control panel. A warning light indicates when the oil reservoir needs refilling, and the machine is shut down automatically when the oil reaches the minimum safe level. Made by **Bijur Lubricating Corp.,** 151 W. Passaic St., Rochelle Park, N. J.

For more data circle MD-97, Page 223

Swivel Joints

Movement in metal piping connected to moving or movable machinery is provided by use of series 600 type S swivel joints, offered in sizes from ½ to 2 in. in four styles for high pressures and/or high temperatures. All have malleable iron casing and steel ball. The 1½ and 2-in. sizes have steel nut and can be furnished in all steel construction on special order. When equipped with Barco 11 MS all metal gaskets, the 1½ and 2-in. sizes are suitable for working pressures up to 2000 psi and are recommended for hydraulic applications on die casting and plastic injecting machines where protection



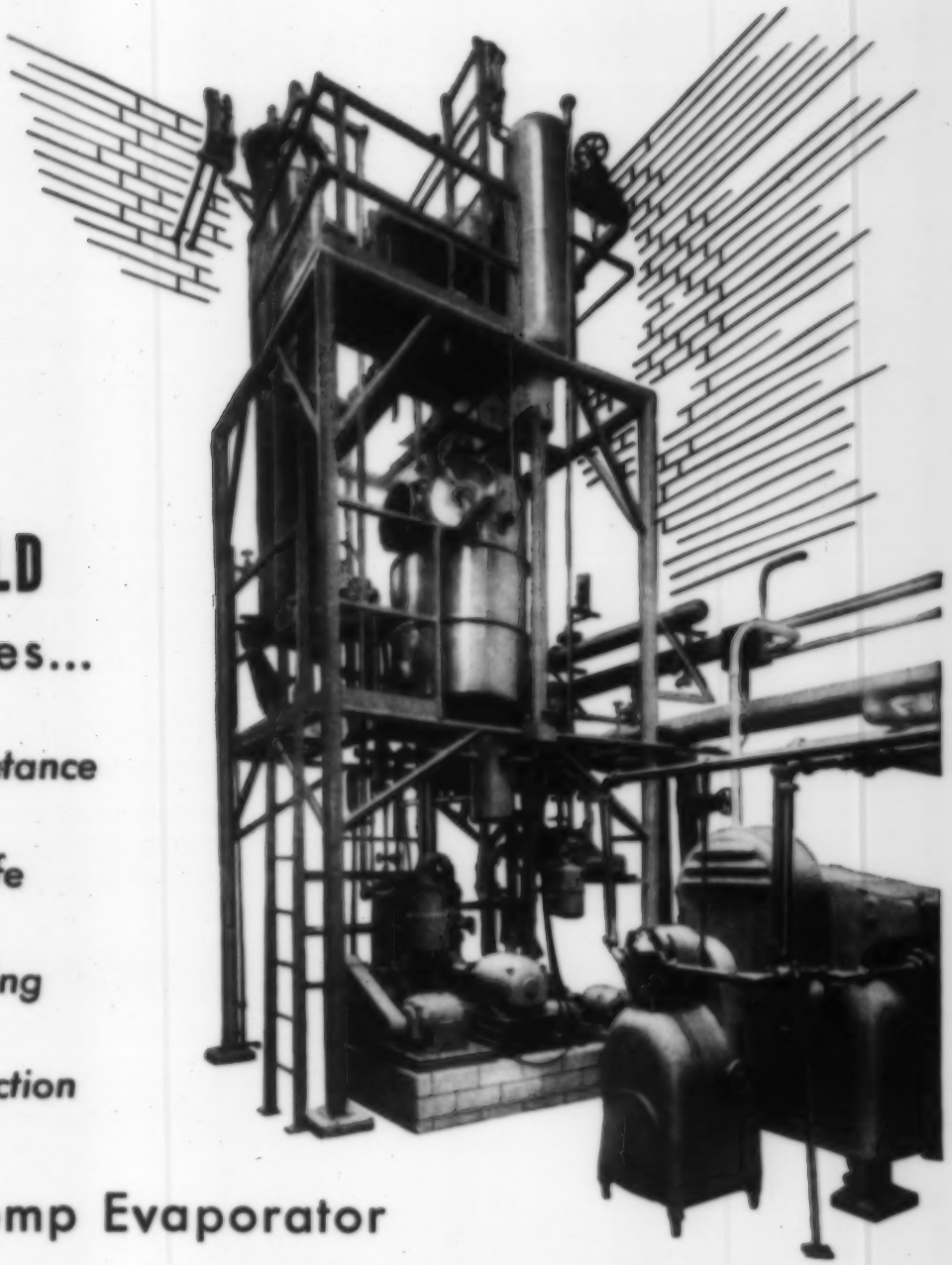
TRENTWELD
tubing gives...

*corrosion resistance

*long service life

*ease of cleaning

*product protection



in Lo-Temp Evaporator

This Mojonnier Lo-Temp Evaporator is designed to remove water from heat-sensitive liquid foods, pharmaceuticals and chemicals, at temperatures as low as 40F. Heart of the evaporator is made of nests of TRENTWELD stainless steel tubing.

TRENTWELD tubing is an ideal choice for this application. For TRENTWELD stainless tubing resists the corrosive attack of both the product itself, and the ammonia refrigerant pumped inside the tubing. And TRENTWELD stainless is inert . . . protects the product from contamination. But that's not all—TRENTWELD comes-clean with an absolute minimum of effort.

So when you have a tubing application check first with TRENT. You'll find the largest assortment of sizes and finishes in the industry . . . standard sizes from ⅛" to 40" O.D. – larger sizes on special order. And remember, TRENTWELD stainless and high alloy tubing are products of *tube mill specialists*. You can't buy better than TRENTWELD.

TRENTWELD

STAINLESS STEEL TUBING

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of CRUCIBLE STEEL COMPANY OF AMERICA)

an old principle
—an extraordinary result

ball bearings rolling on a FLAT surface

- *offer less friction*
- *are easy turning*
- *wear longer*

EMSCO
BALL BEARING SWIVEL FITTINGS

It's an old principle, a ball rolling on a flat surface – making a single point of contact, and when applied to a ball bearing swivel fitting you get an extraordinary result – free and easy rotation even under extreme pressures. Compare EMSCO on this point!

Should you take the EMSCO fitting apart – and it's easy to do because it breaks like a union, you'll note a unique packing and ball race design which permits easy adjustment for wear. No expensive return of fittings to the factory for service. Note also how the large fluid passageways and smooth, easy contour of bends reduces turbulence and increases flow.

You'll find an EMSCO ball bearing swivel fitting for almost any application.

GET THE COMPLETE ENGINEERING STORY FROM OUR NEW CATALOG TODAY.

8 BASIC STYLES — OVER 500 MODELS

EMSCO MANUFACTURING COMPANY
BOX 2098, TERMINAL ANNEX
Houston, Texas • LOS ANGELES 54, CALIFORNIA • Garland, Texas
Representatives in principal cities

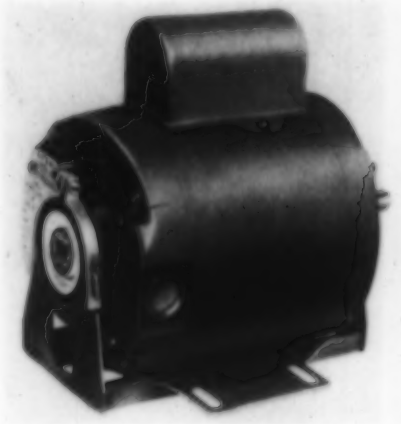
New Parts

against blow-outs is required. Self-aligning design of joints simplifies pipe fitting, eliminates binding and guards against wear. Made by **Barco Mfg. Co.**, Dept. J-28, 500 N. Hough St., Barrington, Ill.

For more data circle MD-88, Page 223

Small Electric Motors

Ranging in rating from 1/6 through 1/3-hp, redesigned line of fractional horsepower motors uses NEMA 48-frame size. Small, lightweight and available in resilient and rigid mountings, motors have



sleeve bearings and nylon thrust washers which permit a variety of mounting positions. Straight-through ventilating system has vent holes limited to the bracket areas. Change of voltage or reversal is accomplished readily by interchanging quick - disconnect plugs in the conduit box. Made by **Westinghouse Electric Corp.**, P. O. Box 2099, Pittsburgh 30, Pa.

For more data circle MD-89, Page 223

Servo Valve

Model FC-2, a two-stage, four-way flow control valve, controls hydraulic flow proportionally to an input current signal. Pilot stage is a hydraulic, nozzle type amplifier driven by a torque motor employing the polarized relay principle. A miniature, high force, positional feedback loop between the torque motor and the main spool position encloses the nozzle stage. Torque motor is available

"What, a variable transformer for only $8.50?"

"Yes, so always try to use its cooler operation, power savings and close accuracy for adjustable a-c voltages in all our designs"

POWERSTAT TYPE 10
PRICE $8.50

Here are two suggestions:

1. If you do not already know the many advantages of variable transformers over rheostats as a source of continuously-adjustable voltage, be sure to write to Superior Electric.
2. If you have been "shying-away" from variable transformers because of costs, get a POWERSTAT variable transformer price list. You may be surprised how economically you can secure all of its operational advantages for the products you design.

You'll find POWERSTATS better as adjustable a-c voltage controls.

POWERSTATS give you the inherent advantages of variable transformer control: cool operation, minimum power cost, "precision-accurate" voltages, long life.

All POWERSTATS have dimensional and wiring features which make them easier to "design into" a product.

POWERSTATS help keep your customers happy. Their ratings are conservative. They always perform as required. Their smoother operation, easier servicing and longer life are "plus" features for your product.

For the best in continuously-adjustable a-c voltage control use variable transformers. For the best in variable transformers always specify POWERSTATS — they are superior.

See Superior Electric's Mobile Display when it visits your area.

THE SUPERIOR ELECTRIC COMPANY

BRISTOL, CONNECTICUT

Manufacturers of: POWERSTAT Variable Transformers • STABILINE Automatic Voltage Regulators • VOLTBOX A-C Power Supplies LUXTROL Light Control Equipment • VARICELL D-C Power Supplies Superior 5-WAY Binding Posts

THE SUPERIOR ELECTRIC COMPANY,
1203 Reynolds Ave., Bristol, Conn.

Please send me a copy of your POWERSTAT Bulletin P252.

Name.....

Company Name.....

Company Address.....

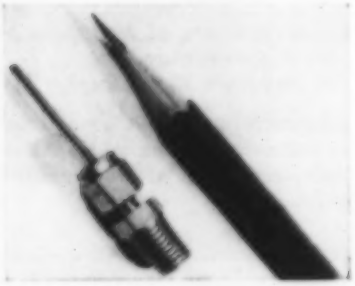
City.....Zone.....State.....

in ranges of 200 to 3000 ohms dc resistance per coil. Valve operates from pressures of 500 to 3000 psi. When operating in a 3000 psi system, a typical valve can deliver a peak power of 10 hp to the load. Valve operates at temperatures to 250 F. Made by **Cadillac Gage Co.**, 20316 Hoover Rd., Detroit 5, Mich.

For more data circle MD-90, Page 223

Capillary Tube Fitting

No special tools are required to install Swagelok tube fittings on 1/16-in. capillary tubing, nor is any preparatory work on the tube required. Seal is obtained with-

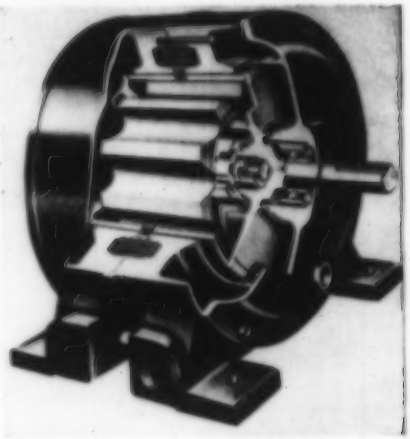


out flaring. Tubing is slipped into the fitting, the nut is turned until a tight seal is obtained, and the installation is ready for operation. Fitting is available in brass, aluminum, steel, stainless steel and Monel. Made by **Crawford Fitting Co.**, 884 E. 140th St., Cleveland 10, O.

For more data circle MD-91, Page 223

Adjustable-Speed Drive

Driven by a constant or variable speed power source, the Dynaspede Coupling delivers torque or speed to suit specific processing requirements. It is a stationary field, liquid cooled, eddy current adjustable speed power transmission device. Effective heat transfer provided by liquid cooling permits wide speed ranges at constant or reduced torque and, under certain conditions, constant horsepower. Various types of easily applied controls, from an alternating current

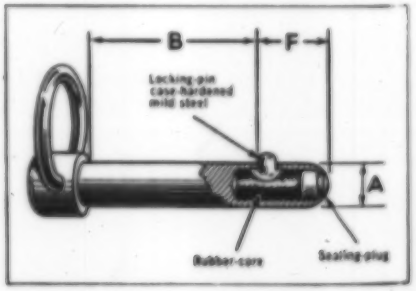


power source, provide stepless speed control. Made by **Eaton Mfg. Co.**, Dynamatic Div., Kenosha, Wis.

For more data circle MD-92, Page 223

Shear Pins

Locking pin is only moving part in this Harley quick-release shear pin. Pin is activated by silicone rubber core which withstands temperatures from −100 to 500 F, as well as moisture, petroleum oil, alkalies and most acids. Foreign matter cannot clog pin nor can it "ice-up". Solid high tensile steel shank gives full shear strength. Release pull can be regulated from 4 to 50 lb by cores of varying degrees of hardness. Various lengths



WHEN IT'S
Special BOLTS
and STUDS
Send your Specifications to
ERIE
40 years' experience in making special bolts, studs, nuts for specific job requirements.

10 INTEGRATED COMPANIES
BARIUM
STEEL CORPORATION
WORKING IN STEEL, ALUMINUM MAGNESIUM, FIBERGLASS

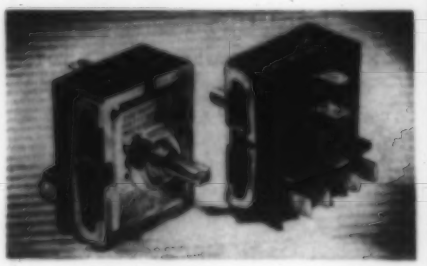
REPRESENTATION IN PRINCIPAL CITIES

are available with diameters ranging upward from ¼-in. Offered by **Harley Patents Inc.**, Dept. 26, 607 Fifth Ave., New York 17, N. Y.

For more data circle MD-93, Page 223

Motor-Reversing Switches

Single phase motors up to 2 hp can be controlled by Diamond H rotary motor-reversing switches. Switch bodies measure only 1 27/32 x 1 21/32 x ⅞ in., but units are rated from ½ to 1 hp, 120 v and up to 2 hp and 20 amp, 240 v ac only. Circuits are available for basic motor types with

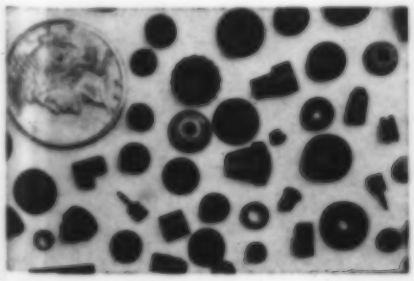


"off" in center and two speeds each side of center; "off" in center with one speed each side; or full rotary, four positions. Spade terminals facilitate wiring. Spindles can be extended through back of base to provide unitized control of other equipment, or allow ganging of switches. Made by **Hart Mfg. Co.**, 110 Bartholomew Ave., Hartford, Conn.

For more data circle MD-94, Page 223

Miniature Molded Parts

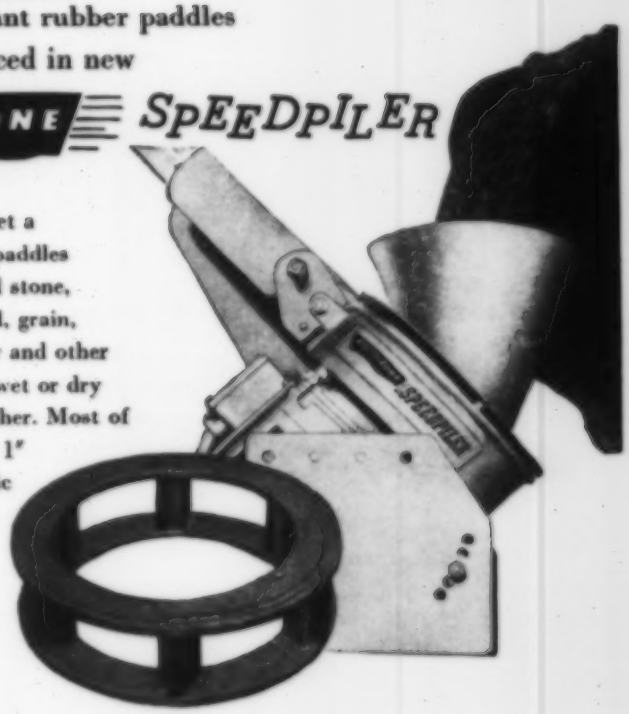
Complex custom molded rubber parts are produced in miniature with dimensional tolerances as close as ±0.001-in. by means of



ROTH RUBBER

Abrasion resistant rubber paddles are easily replaced in new

PETTIBONE SPEEDPILER



Whirling at 2000 feet a minute, six rubber paddles throw sand, crushed stone, coal, chemicals, feed, grain, salt, sugar, fertilizer and other bulk materials . . . wet or dry . . . 47 feet and farther. Most of this material, up to 1" in size, has a terrific abrasion quality.

Roth Rubber Engineers Solved This Problem

Roth engineers specified and formulated just the right rubber to resist this tremendous abrasive action. Also solved was the problem of fast, easy, inexpensive replacement. Roth engineers can solve *your* rubber problems. There's no obligation for Roth technical assistance. Write us a description of your rubber problem or your rubber requirements. We'll be glad to help.

Engineers and Rubber Buyers!

Write for your free Roth Rubber Sampler. This unusual kit contains actual rubber samples with hardness from 5 to 100 Durometer . . . gives ASTM specs and lists uses for each sample. Sorry, but offer must be limited to engineers and rubber buyers only.

Please ask for Roth Rubber Sampler No. MD-5

Custom manufacturers of Industrial Rubber Products since 1923

ROTH RUBBER COMPANY

1856 S. 54TH AVENUE • CHICAGO 50

YOU can hold a SPEED record too-

NEW MILE RECORD
Aug. 7, 1954 - 3:58.8

Performance that will far out-distance obsolete hand methods in your ASSEMBLY DEPARTMENT!

DPS POWER SCREWDRIVERS and SELECTIVE PARTS FEEDERS

are the answer!

● While these champions may be tops in their field, DPS Assembling Equipment is a leading factor in the American Industrial Field—And not only in the matter of speed, (with a record of driving screws at one per second) but in economy effected through labor-saving and greater accuracy through the elimination of manual handling.

Whatever your Feeding and Assembling Operations may be, write us . . . Also send sample assembly for production estimate.

DPS BOWL-FEEDERS

● Designed to feed light, fragile parts that might not withstand tumbling. Operates on the VIBRATORY PRINCIPLE . . . Provides fully automatic, oriented, single line feeding to Grinding, Packaging, Inspecting and many other automatic machines and operations.

DETROIT POWER SCREWDRIVER CO.

2801-A W. FORT ST. DETROIT 16, MICH.

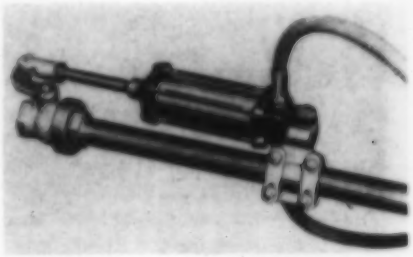
New Parts

injection molding. Among the parts illustrated are a spraying valve seal, relief valve, phonograph tone arm support, transformer terminal insulator, refrigerator bumper and various hydraulic seals. Shapes and designs can be made to specifications, and many compounds of Neoprene, Buna N and silicone synthetic rubbers can be used to make the parts. Made by **Minnesota Rubber & Gasket Co.**, Dept. KP, 3630 Wooddale Ave., Minneapolis 16, Minn.

For more data circle MD-95, Page 223

Ball Valve

Air-operated ball valve, for remote control use, makes practical the use of control panels for convenient operation of many scattered valves. Valves are leakproof,



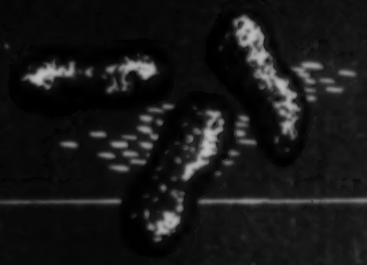
deliver full round flow, open and close quickly and do not require maintenance. They are available in sizes from ⅜ to 2 in. Made by **Rockwood Sprinkler Co.**, 38 Harlow St., Worcester 4, Mass.

For more data circle MD-96, Page 223

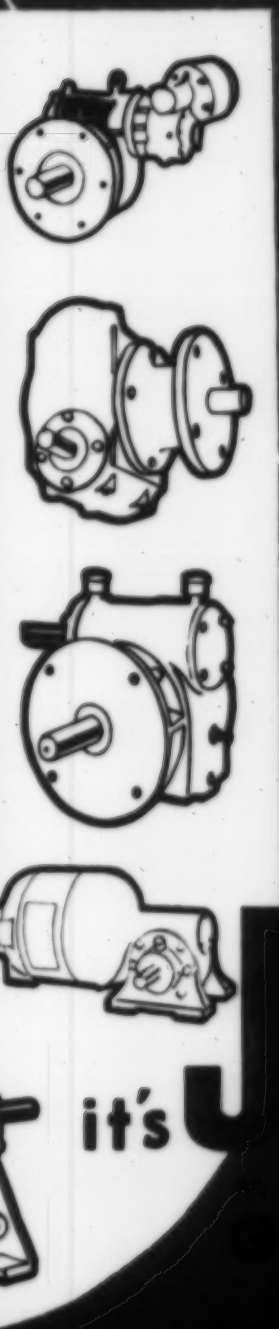
Electromagnetic Clutch

Compact and lightweight, model C130 clutch exhibits high torque characteristics. Although designed for on-off service, it will deliver, for short periods of time, intermediate torque values through the mechan-

From Atomic Energy ... to Peanuts



the right speed ... the right power



From the gigantic atomic energy plants and laboratories where Jamesbury speed reducers and gear motors are so extensively used in this critical production—to the quality and quantity control of processing of peanuts ...

These two applications may be dramatically extreme, but they help to illustrate the wide versatility of the Jamesbury line. What-ever your industrial operation is, when it comes to controlling speed and power, ask Jamesbury.

Write for Jamesbury engineering catalog on Gear Motors and Speed Reducers. This engineering data catalog is used extensively as a reference book for both Gear Motors and Speed Reducers.

it's

AUTOMATIC SPRINGS ...
ARE QUALITY CONTROLLED*
FLAT & POWER SPRINGS
CLIPS AND SHAPES
COMPRESSION SPRINGS
EXTENSION SPRINGS
TORSION SPRINGS
ENGINE VALVE SPRING
* Quality control is maintained in every spring made by AUTOMATIC. This starts with control of the quality of the raw materials used, and continues on through every step and stage of manufacture to the finished product. For quality controlled springs—quality controlled to fit your particular need—specify AUTOMATIC SPRING on your next order.
for quality springs "Automatically" think of
AUTOMATIC
SPRING COILING CO.
4043 West Thorndale Ave., Chicago 30, Ill.

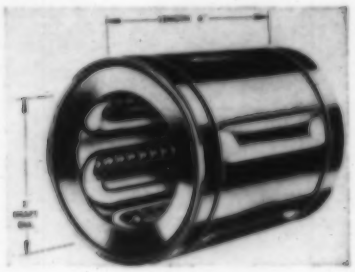
New Parts

ism of slipping at low excitation. Static torque is 9 lb-in. Clutch does not require precise alignment of the driven member with respect to the driving member; appreciable angular misalignment will not affect operation. The driven member comprises three individual shoes to prevent chattering upon engagement. Standard clutches have coils for 100 ±10 v dc; coils for 6, 12, 28, 40 v and other voltages can be furnished. Clutch is 1 5/16 in. in diameter, 2 45/64 in. long overall. Made by **Dial Products Co.**, 55 Evergreen Ave., Newark 5, N. J.

For more data circle MD-97, Page 223

Linear Ball Bearings

Heavy-duty Ball Bushings are large size linear ball bearings for ¼ to 3-in. diameter shafts. Bushings can be used on machinery and heavy equipment employing



linear motion. On guide rods, for example, they afford a long life of exact precision alignment, since very low friction eliminates wear as well as the possibility of binding or chatter. Made by **Thomson Industries Inc.**, Manhasset, L. I., N. Y.

For more data circle MD-98, Page 223

Decade Capacitors

The use of polystyrene capacitors and precision structural components provides high stability and accuracy and low dissipation factors in precision Dekapacitors. Any incremental capacitance value can be selected throughout the 0 to 1 mfd range within ± 1 per cent accuracy by new style Dekadial. Unit provides 1000 incremental steps of

BIG HOBBERS for ILLINOIS GEAR

This mammoth new gear hobbing machine, now in operation at Illinois Gear, is the most accurate and largest machine in existence for fast precision hobbing of BIG gears. Equipped with 12" x 15" ground hobs, the largest ever made, it does precision work on blanks up to 100,000 lbs. and 134 inch diameter, 3½ inch C.P. and 54 inch face. Spur, helical and worm gears can be cut to spacing tolerances as low as .0003 inch.

Whatever your needs, you'll find the right machine and tool for your job at Illinois Gear.

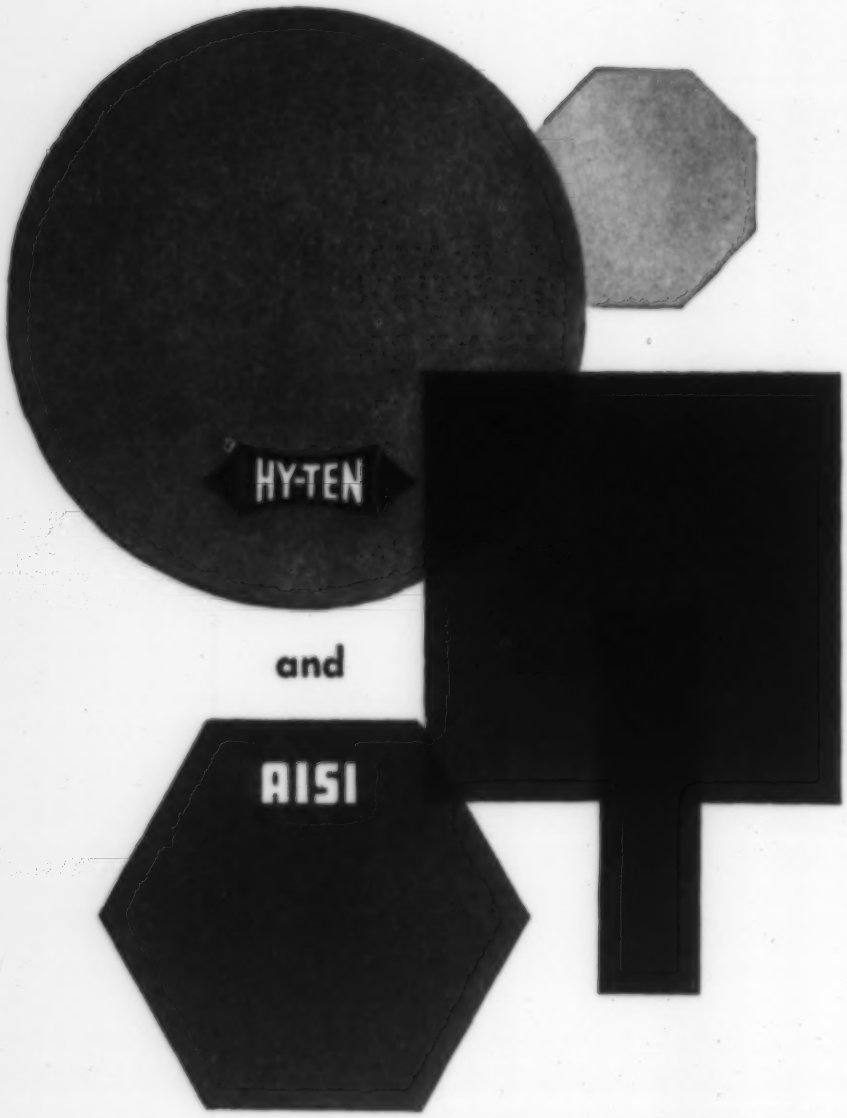
Look for this mark (ILLI) . . . the symbol on finer gears

ILLINOIS GEARS Reg U S Pat Off

Gears for Every Purpose ... one gear or 10,000 or more

ILLINOIS GEAR & MACHINE COMPANY

2108 NORTH NATCHEZ AVENUE • CHICAGO 35, ILLINOIS



bars, billets and forgings in sizes, shapes and treatments for every need!

Wheelock, Lovejoy & Company, Inc., can fill your alloy steel requirements promptly. This applies to both standard AISI and SAE steels and to our own HY-TEN steels – "the standard steels of tomorrow". Take advantage of our seven strategically located warehouses. All of them can supply these steels in the form and quantity you need. Every warehouse, too, is staffed with expert metallurgists who are ready to serve you.

Write today for your FREE copies of Wheelock, Lovejoy Data Sheets. They contain complete technical information on grades, applications, physical properties, tests, heat treating, etc.

near you . . .

Warehouse Service – Cambridge • Cleveland • Chicago
Hillside, N. J. • Detroit • Buffalo • Cincinnati
In Canada – Sanderson-Newbould, Ltd., Montreal and Toronto

WHEELOCK, LOVEJOY & COMPANY, INC.
133 Sidney Street, Cambridge 39, Mass.

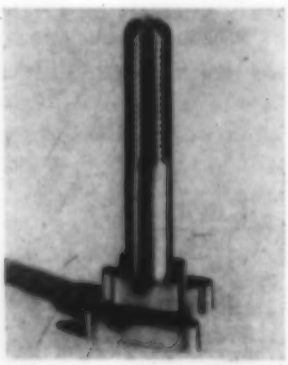
New Parts

0.001-mfd each. Direct capacitance readings are made on the stacked deck of dials. Outer and middle dials have nine positions for selection of tenths and hundredths of microfarads, respectively. Thousandths of microfarads are selected by the inner dial, which is provided with ten scale divisions. Dekapacitor is enclosed in a cylindrical shield 3 in. in diameter and 6 in. deep behind the panel. Made by **Electro - Measurements Inc.**, 4312 S. E. Stark St., Portland 15, Oreg.

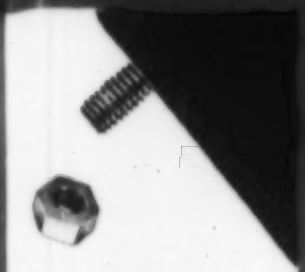
For more data circle MD-99, Page 223

T-Slot Bolt

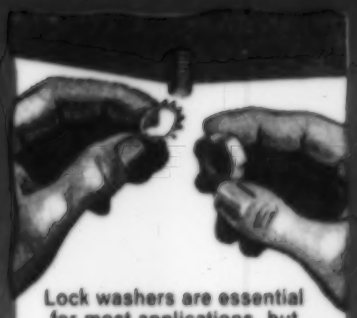
Concave head of this bolt automatically cleans out the slot as the bolt travels on the work table, pushing dirt and chips to the center of the slot instead of to the sides. This construction adds more than 50 per cent to the normal bearing surface of the head, and concentrates stress on inner slot edges, which are stronger than outer edges. Bolts are of SAE 4140 steel, Austempered to a C-scale Rockwell range of 42-45, providing tensile strength of 200,000 psi. Standard bolts are available ½-in. in diameter, from 2 to 18 in. long under the head; ⅝-in.



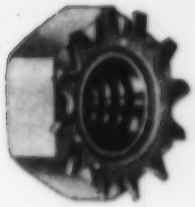
Why KEPS® save time...stay tight!



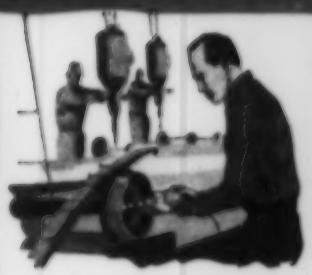
Loosening of ordinary nuts due to vibration is both dangerous and costly.



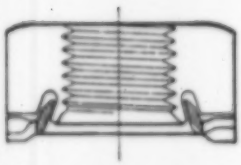
Lock washers are essential for most applications, but often hard to handle.



. . . except when nuts and lock washers are PRE-ASSEMBLED . . . as KEPS.

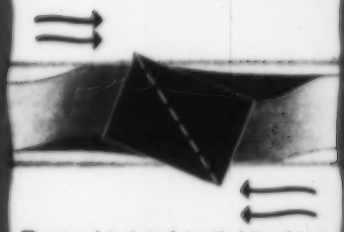


Then, awkward and costly separate lock washer handling is eliminated.

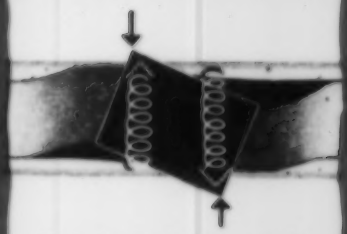


Nut and lock washer are mechanically pre-assembled as an integral unit.

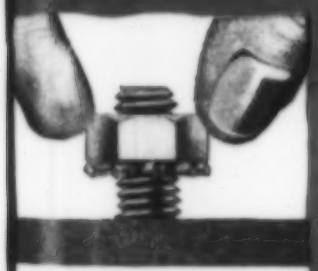
Shakeproof Lock Washers on KEPS lock tight because the teeth bite.



Tapered-twisted teeth bite deep to set up powerful resistance to any backward rotation.



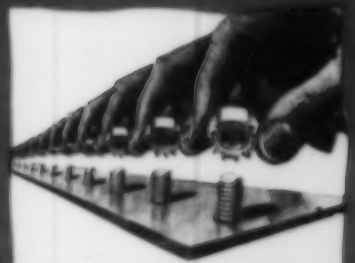
Spring tension makes each tooth bite even deeper as vibration increases.



arting KEPS is easier . . . Free running action makes driving faster, saves assembly time.

Washers can't drop off, can't be wasted or "forgotten."

Standards and specials meet a wide variety of requirements.



With KEPS, you get tight, efficient fastening every time.

Free Sample Kit

Now . . . make your own tests! See for yourself how KEPS can save time in the assembly of your product. Write for your free sample kit today!

SHAKEPROOF

"Fastening Headquarters"®

DIVISION OF ILLINOIS TOOL WORKS

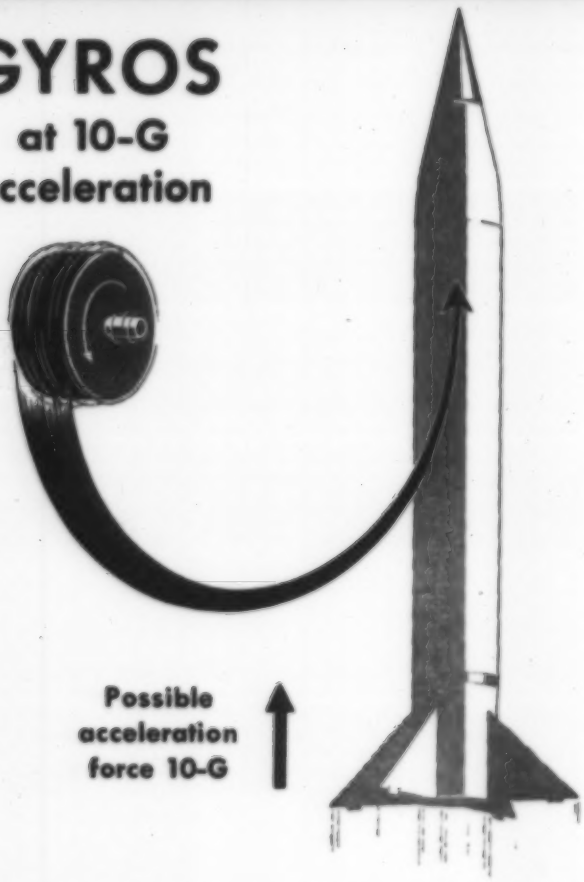
St. Charles Rd., Elgin, Illinois • Offices in Principal Cities

In Canada: Canada Illinois Tools Limited, Toronto, Ontario

WORLD'S BROADEST LINE OF MASS-ASSEMBLY FASTENINGS

SINCE 1915 LEADERS IN AUTOMATIC CONTROL

GYROS
at 10-G acceleration



The gyroscope in a missile guidance system must be able to withstand acceleration forces up to 10 G's in any direction. This gyroscope, designed and developed by the Guided Missile Development Division of the U. S. Army and the Ford Instrument Company, will function under this acceleration. Tests have shown these gyros to be accurate to 1/50° per hour drift, or better.

For forty years, Ford has been building gyroscopes, at first for navigation devices, later for stabilization in many fire control problems. Ford designed and manufactured gyros have been in the stabilization systems of heavy battleship guns, in missiles and torpedoes and in delicate airborne instruments. Stable platforms and guidance systems have been outstanding achievements of Ford Instrument Company engineers.

Since 1915, the engineers at Ford Instrument Company have specialized in such equipment as computers, controls, and servo-mechanisms in hydraulics, electronics, mechanics and magnetics for the Armed Forces and for industry. If you have problems in any of these fields, it will pay you to discuss them with Ford engineers.

49

FORD INSTRUMENT COMPANY
DIVISION OF THE SPERRY CORPORATION
31-10 Thomson Avenue, Long Island City 1, N.Y.

ENGINEERS
of unusual abilities can find a future at FORD INSTRUMENT COMPANY. Write for information.

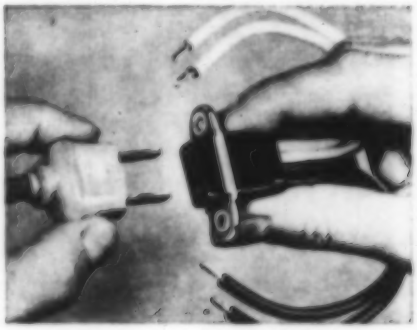
New Parts

diameter, from 2½ to 18 in. long under the head; ¾-in. diameter, from 2½ to 24 in. long under the head. They are also available in ⅞, 1, 1⅛ and 1¼-in. diameters. **Made by Standard Parts Co.**, 1000 Broadway, Bedford, O.

For more data circle MD-100, Page 223

Miniature AC Outlet

Mini-spACe outlets, prewired with two leads on each contact, are installed by riveting or eyeleting into a panel, matching the black and white leads to those of adjacent outlets and interwiring

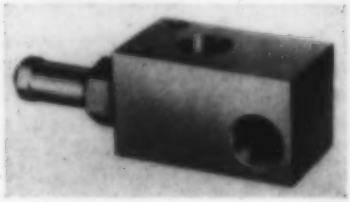


with wire nuts. Designed for parallel wiring in multiple outlet power distribution systems, outlets mount with 1⅛-in. mounting hole centers. They take less than ½-in. panel space between mounting holes and less than 1 in. of space behind mounting panel. The 12-in. long, 14-gage, UL-approved double leads are attached to integral strain relief tabs on each contact. Outlets are rated 15 amp at 125 v and 10 amp at 250 v. **Made by Alden Products Co.**, 117 N. Main St., Brockton 64, Mass.

For more data circle MD-101, Page 223

Relief Valve

Spring - loaded, guided piston type relief valve for oil is used to control pressure in clamping or feed circuits. Use is recommended where pressure is controlled by a continuous flow through the relief valves. In operation, pressure force on the piston is equal to the spring force against it. As pressure increases, spring is com-



pressed and the piston uncovers the outlet ports. Fluid in the spring cavity dampens the valve and prevents chatter. Characteristics of valve include steady pressure, quick response and long life. Series is available in a cartridge style for oil at 10 to 600 psi with a hand knob pressure adjustment, and in ⅜, ½ and ¾-in. pipe sizes. Made by **Fluid Controls Inc.**, 1284 N. Center St., Mentor, O.

For more data circle MD-102, Page 223

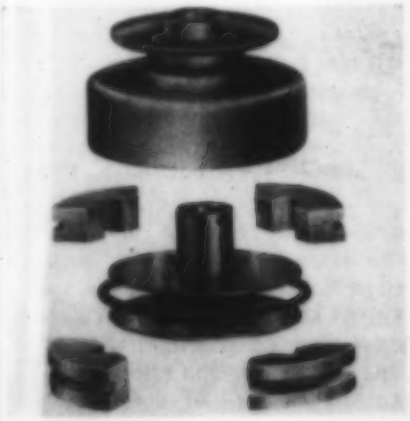
Molding Compound

FM 11679 Black, a two-step, cord-filled phenolic molding material, has minimum flexural strength of 18,000 psi and minimum Izod impact strength of 14 ft-lb per in. of notch. Plasticity is medium to hard; compressive strength is 18,000 psi. Molded parts withstand temperatures to 250 F. Made by **Fiberite Corp.**, Winona, Minn.

For more data circle MD-103, Page 223

Centrifugal Clutch

Only moving parts of this automatic spider type clutch are four friction segments which ride on a rubber spider and are held in position by a garter spring. Self-energizing unit has a stamped



Why Aircraft Designers, too, Specify FORMSPRAG Full Complement Clutches

Aircraft designers are putting the many advantages of Formsprag Full Complement Clutches to work in a wide range of applications.

The reasons are four—all easily seen: (1) Aircraft needs the greatest torque capacity for size and weight – that's why they're used in oil drilling machinery. (2) Aircraft uses Formsprag for its precision operation without backlash—for this reason, too, press manufacturers use Formsprag. (3) Aircraft depends on the long life available with Formsprag Full Complement Clutches – automobile manufacturers are taking advantage of this feature, too. (4) Aircraft is pleased with Formsprag's low maintenance due to design simplicity—as are packaging machinery manufacturers.

It's true that aircraft clutches are specials and that Formsprag will build specials for you. But many industries are deriving these special benefits from Formsprag's *standard* clutches in over-running, backstopping, and indexing applications. Every Formsprag Clutch, whether it's a *special* or a *standard*, has only four basic parts and operates as simply as this:

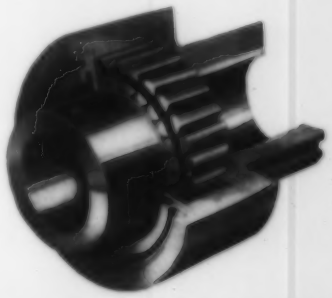
Torque is delivered from one concentric race member to the other through the full complement of sprags. When torque is applied through the driving member, the sprags are instantaneously engaged between driving and driven member by an energizing spring. When torque is removed, all the sprags release instantaneously

WRITE NOW FOR THIS FORMSPRAG CATALOG

•

Distributors in Principal Cities.

FORMSPRAG Clutches



FORMSPRAG COMPANY • 23803 Hoover Road, Van Dyke, Michigan

FELT

by FELTERS

means product improvement

When you want good wear resistance combined with resilience — or a firm material that resists oils and moisture — find out what Felt by Felters can do for you.

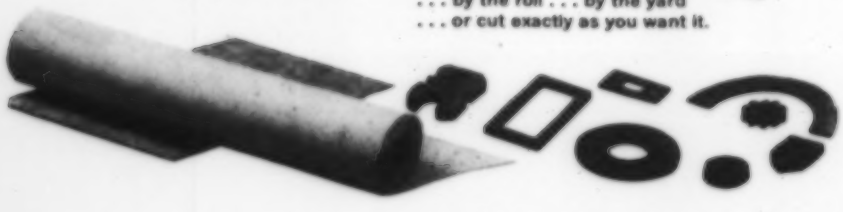
The new 24-page Felters Design Book describes many grades of felt and their uses. For your copy, just drop us a line.

THE FELTERS CO., 218 South St., Boston, Mass.

FELTERS S.A.E. F-13 and F-15 are grades of felt recommended for sound deadening chassis strips, spacers, dust shields and mechanical purposes when abrasion and wear are not important factors.

FELTERS FELT

. . . by the roll . . . by the yard
. . . or cut exactly as you want it.



New Parts

steel housing, with half of pulley serving as part of the housing. Adaptable to V-belt, sprocket or direct coupling drive, the clutch is operated by centrifugal force controlled by engine throttle. It can be used in gasoline engine powered equipment up to 3½ hp. Operation can be in either direction. Made by **Automatic Steel Products Inc.**, Mercury Clutch Div., 1201 Camden Ave. S. W., Canton 6, O.

For more data circle MD-104, Page 223

DC Relay

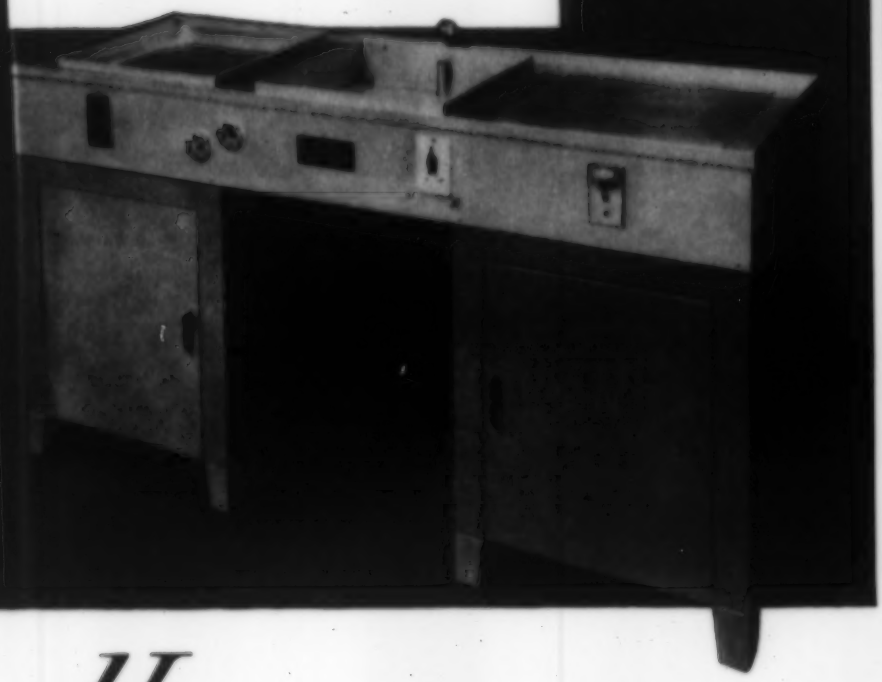
Model 100-B relay combines high sensitivity with thorough wiping action on each contact. Electrical consumption is only 25-milliwatt per contact. Bounce and chatter are eliminated by the built-in wiping action in the contact movement. Drop-out can be adjusted to about 65 per cent of the pick-up. Capacity

is up to 1 amp inductive and 3 amp resistive load with coil resistance to a maximum of 30,000 ohms. Contact arrangement can be one of various combinations of single or double-pole, single or double-throw contacts. Relay measures 1¼ in. in diameter x 3⅝ in. above mounting line. Made by **Hedin Tele Technical Corp.**, 640 W. Mt. Pleasant Ave., Livingston, N. J.

For more data circle MD-105, Page 223

Pedestal-Mounted Pump

Stainless steel Centri-Chem centrifugal pump is now available with a pedestal mount designed to permit belt drive or direct coupling with any standard motor. Mount is a single precision-finished iron casting with a smooth, heavy-duty double ball bearing unit and a stainless steel shaft in accurate alignment with the base plate. Thrust shoulders machined into the shaft rest on bearings that eliminate end thrust and take up the radial load. Reduced overhang per-



Automatic film developing sink with top section of Stainless Steel.

Forming edges of top on 100-ton press brake.

Welding z-sections to underside of cooling tray.

How Stainless Steel helps make film developing automatic

DURABILITY, corrosion resistance and good looks are built into this automatic photographic developing sink through the use of Stainless Steel for the entire top section, including the two trays and the center bowl.

Metlmex Corporation, Lewistown, Pa., fabricator of this sink, makes a variety of products, working with both Stainless Steel and carbon steel. Fabricating equipment is used interchangeably with no special tools for working Stainless. The only difference in shop procedure lies in precautions taken to avoid marring the smooth surface of Stainless Steel.

Stainless Steel offers a unique combination of properties—plus ease of fabrication. It's the answer to a wide range of design problems. And when you use it, be sure you get service-tested USS Stainless Steel.

FABRICATING FACTS

Sheets are sheared to size in a ¼" capacity squaring shear and edges are then formed on a 100-ton press brake.

Front, sides, bowl and trays are assembled to form a complete integral stainless steel top unit. Metallic-arc, heliarc, and spot methods are employed in welding temperature controlled trays and cabinets. Developer and fixing trays are attached to unit by riveting one side to stainless steel hinge permitting mechanical agitation.

Stainless steel panels are easily lock seamed to form center bowl section.

After assembly, entire unit is ground and polished to remove weld marks.

SEE THE UNITED STATES STEEL HOUR.

It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

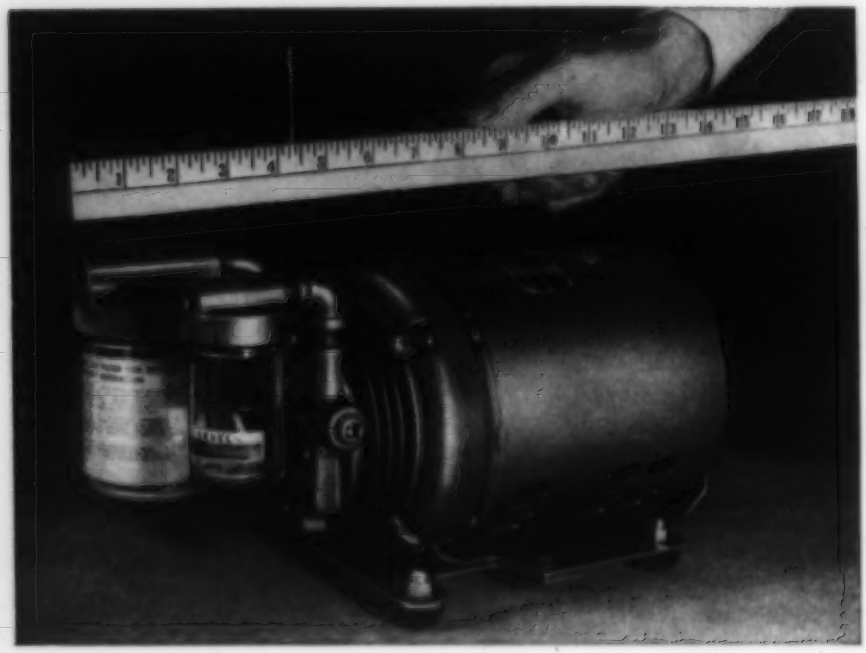
USS

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

5-456

UNITED STATES STEEL



New Gast Model 0211
integral-motor Air Pump
weighs 1/3 less — is a truly

COMPACT COMPONENT

In addition to a nine-pound weight reduction,* this new Gast rotary-vane Air Pump provides many other advantages.

New pump housing is more streamlined, more compact, better-looking! New G. E. Form "G" motor has pump rotor mounted on motor shaft, assuring smoothness and dependability. Light-weight sliding vanes provide positive, pulseless air delivery.

Resilient, rubber-cradled mounting dampens vibration and hush–quiets the entire unit. Pump delivers up to 1.3 c.f.m. running open at 1750 r.p.m., with 1/6 h.p. motor using only 3.8 amps.

Designed for original equipment applications, Model 0211 produces a maximum 25 p.s.i. or 27" vacuum — ideal for many automatic machines, industrial instruments and controls. Present O.E.M. uses include paper feeding in packaging, printing frames, liquid solvent agitators. Also used as a portable laboratory vacuum and pressure source.

Consider the advantages *your* product can derive from this new, compact component... *and write for Bulletin 1254 and "Application Ideas" Booklet!* Gast Manufacturing Corp., P. O. Box 117-P Benton Harbor, Michigan.

*Now only 22 lbs.

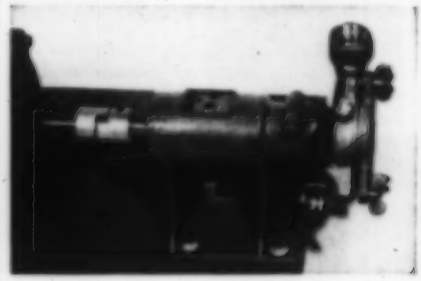
Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- AIR MOTORS TO 4 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

New Parts

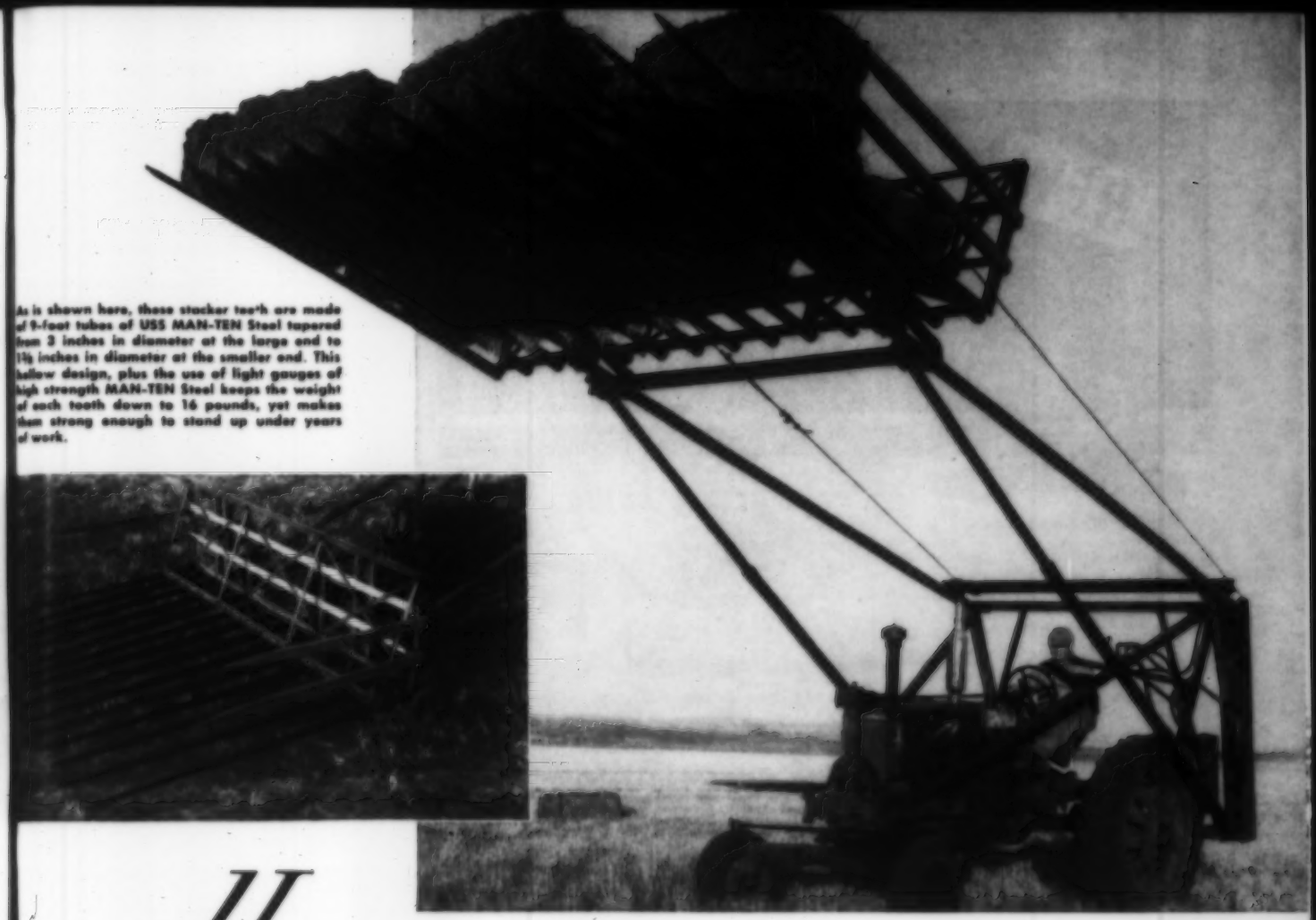


mits rotation of pump in any position without obstruction by pedestal parts. Heavy pads insure vibration-free performance when the unit is mounted on a concrete or steel bedplate. Made by **Eco Engineering Co.**, 12 New York Ave., Newark 1, N. J.

For more data circle MD-106, Page 223

Digital Decade Counters

Printed circuits are employed by both A and B type digital decade counters, each of which is available in three variations. The A group has decades with staircase output of voltage proportional to count so that output can be recorded on direct-writing oscillograph. The B group has decades with four-line coded output which can be used to operate mechanical printers. Both types are applied to models 100, N-100 and N-101 electronic counters which will accept input pulses at rates varying from 0 to 100,000 counts per second. Both the N-100, designed for plate supplies of 150 v, and the N-101, for plate potentials of 300 v, have maximum counting speed of 100,000 counts per second. Count is displayed on illuminated, numbered panel as a single digit in the decimal system. In model 100, count and final value are displayed on



As is shown here, these stacker teeth are made of 9-foot tubes of USS MAN-TEN Steel tapered from 3 inches in diameter at the large end to 1½ inches in diameter at the smaller end. This hollow design, plus the use of light gauges of high strength MAN-TEN Steel keeps the weight of each tooth down to 16 pounds, yet makes them strong enough to stand up under years of work.

How USS MAN-TEN Steel was used to give greater strength and longer life to stacker and rake teeth!

WOODEN TEETH, long used in hay stackers, had many disadvantages for the farmer-user. They would crack easily when snagged on the ground, break under loads of baled hay and warp out of shape from dampness. To give the farmer a better, stronger and longer-wearing product, the Reiten Manufacturing Company, Cooperstown, North Dakota decided to make these teeth of steel. The steel they selected as having the necessary properties to do this job most efficiently was USS MAN-TEN HIGH STRENGTH STEEL.

Now made of USS MAN-TEN Steel, the finished teeth simplify considerably the handling of loose or baled hay. They slip easily under bales, without snagging or catching; they are so much stronger than wood that they can readily stand up under the weight of baled hay without failing; and they wear so much longer and so reduce repairs and replacements that their slightly higher initial cost is offset many times.

USS MAN-TEN—one of the family of outstanding USS High Strength Steels—has a yield point 50% higher than structural carbon steel and it affords high resistance to fatigue, abrasion and impact. As was the case here it can be used to build maximum strength and stamina into vital parts and still keep the weight within reasonable and economical limits – both for the manufacturer and user.

SOON TO BE ISSUED

Our new "Design Manual for High Strength Steels" contains comprehensive and practical information that you will find extremely useful in designing your product for greater economy and efficiency by the use of high strength steels. Watch our future advertisements for the announcement of the availability of this important publication.

See "THE UNITED STATES STEEL HOUR"—Televised alternate weeks—Consult your newspaper for time and station.

UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH · TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS MAN-TEN HIGH Strength STEEL

USS

5-854

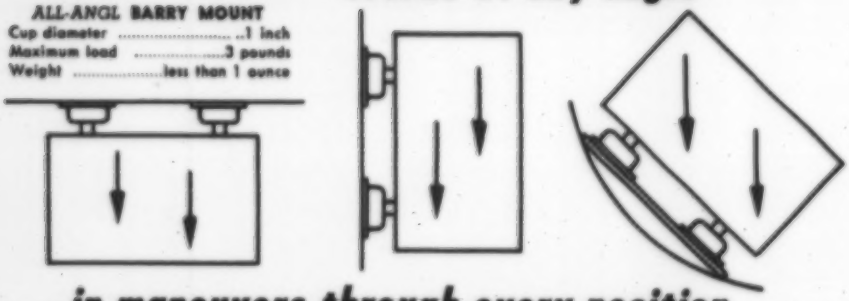
UNITED STATES STEEL

NEW

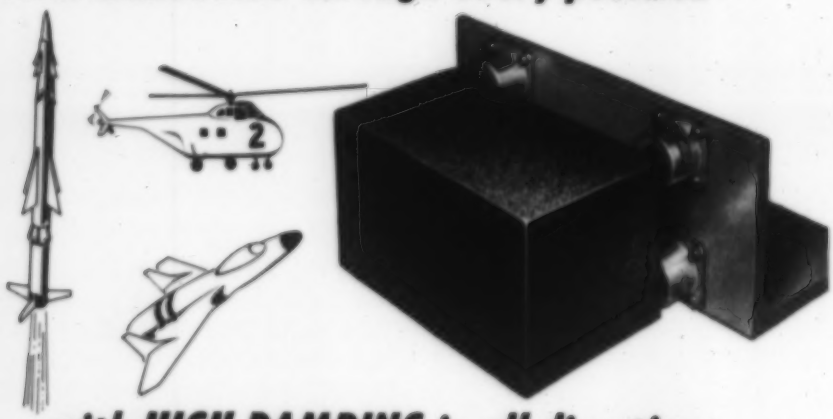
ALL-ANGL BARRY MOUNT

ALL-ANGL BARRY MOUNT
Cup diameter ..... 1 inch
Maximum load ..... 3 pounds
Weight ..... less than 1 ounce

Works at any angle



...in maneuvers through every position



...with HIGH DAMPING in all directions

Now you can forget all limitations on mounting positions for delicate apparatus. You can design for easiest installation and best space utilization, because the new Barry ALL-ANGL vibration isolator works in any position. Upside down, on a bulkhead, at any slant — position means nothing to this new BARRYMOUNT.® Damping is exceptionally high in all directions; transmissibility at resonance is less than 3. The ALL-ANGL mount is interchangeable with other miniature BARRYMOUNT isolators.

This isolator is the answer to your toughest vibration-protection problems. Let us show you what it will do for you — at the New York I. R. E. Show; or write for Bulletin.

THE BARRY CORP.

722 PLEASANT STREET
WATERTOWN 72, MASS.

SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

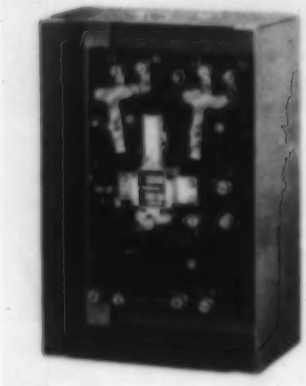
New Parts

direct-reading meter. Counting units can be cascaded to provide any desired counting capacity. External switching accessory permits selection of output pulse at any value from 1 to 9. Made by **Brush Electronics Co.**, 3405 Perkins Ave., Cleveland 14, O.

For more data circle MD-107, Page 223

Time Delay Relay

Combining functions of a time delay relay and a contactor, this new relay provides any delay from ½ to 6 seconds for 120, 240, 460, 600 v, 60 cycles ac. It is also available for other frequencies, as well as for dc operation. Relay handles



motor loads directly. For repeated cycling, with external contact closed, it repeatedly closes and drops out at preset intervals. Relay has double break silver contacts with wiping action, clapper type magnet with oilite bearings at pivot, vacuum impregnated coil, low loss silicon steel magnet frame. Semi-dust tight cabinet fastens by means of a screw on the bottom and has four knockouts for either ½ or ¾-in. conduit. Made by **Automatic Switch Co.**, 391 Lakeside Ave., Orange, N. J.

For more data circle MD-108, Page 223

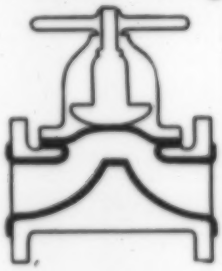
Miniature Motors

Available as either hysteresis or ac induction units, Frame 43 miniature, high-power motors are for continuous-duty, class A service.

(*Continued on Page 278*)

FOR METAL!

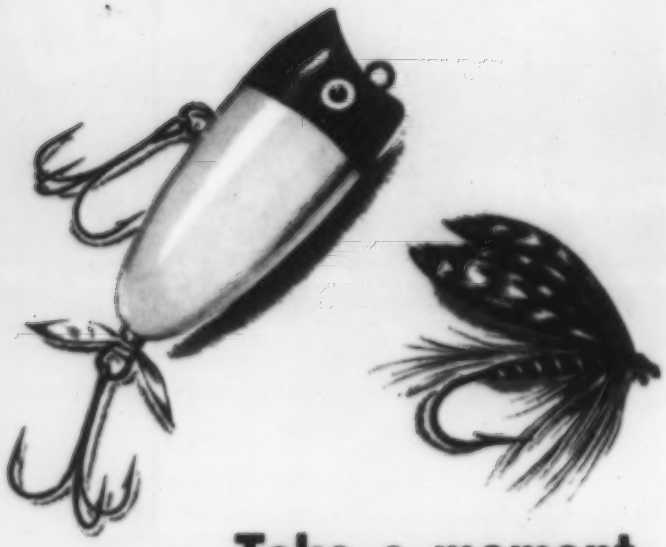
in Valve Linings



Valve Diaphragms

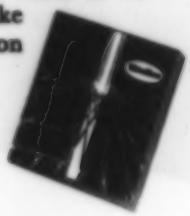
Gaskets

O-Ring Seals



Take a moment . . .

A second's glance will tell you there's a difference in purpose as well as shape between the plug and fly above. Companies differ in the same way and it won't take long to find that Titeflex is a "different" kind of company. Take originality—years of work on specially engineered jobs have made Titeflex people original in their thinking so you won't get routine answers to your $64 questions. More important, they know their business and you'll find you can talk over your troubles with them. And above all, Titeflex people are friendly, anxious to help. If you want to be treated individually, differently, you may like Titeflex a lot. Many others do. The coupon below will bring us together.

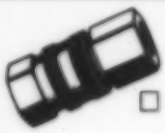


Titeflex

☐ Seamed and Seamless Metal Hose

☐ Ignition Harness and Shielding

☐ Precision Bellows



☐ Quick-Seal Couplings

Titeflex, Inc.
Industrial Products Division
508 Hendee Street
Springfield, Mass.

Please send me without cost information about the Titeflex products checked above.

Name_____

Title_____

Firm_____

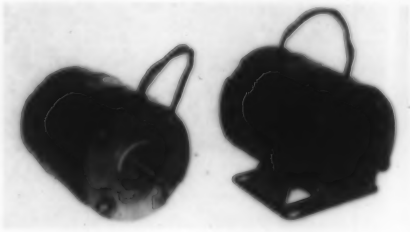
Address_____

City_____ Zone_____ State_____

Left: Fresh water plug for Pickerel and Bass, Right: Fresh water fly for Brook, Brown and Rainbow Trout

New Parts

(*Continued from Page 274*)



Improved design and built-in fan result in low temperature rise with ratings up to 1/6-hp in a frame 4⅜ in. OD x 5½ in. long. Frames and end brackets are heat-treated aluminum, rotor shaft is precision-ground carbon steel, and stator is of insulated silicon-steel laminations, hydraulically rivetted and accurately ground. Induction type motors incorporate rotors that are insulated silicon-steel, pressure die-cast with 99.5 per cent aluminum. Hysteresis type motors have rotors of cobalt steel, machined and heat-treated, then fitted to aluminum spiders, pressed and pinned to the shaft. Motors are designed for easy modification to meet a wide range of requirements. Made by **Instrument Motors,** P. O. Box 5, Acosta St., Stamford, Conn.

For more data circle MD-109, Page 223

Compressed Air Filters

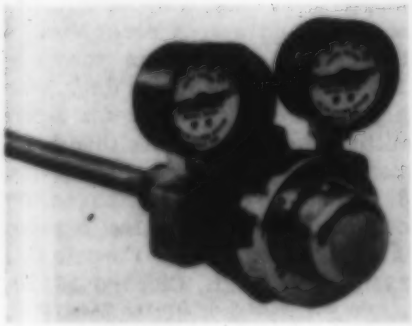
These filters remove water and dirt from compressed air lines to protect air-operated instruments, tools and cylinders. Inlet air is channeled down a center tube to a curved baffle below the filter element where centrifugal action removes dirt and water. A flat lower baffle prevents accumulated water from being picked up by the

air stream. Cleanable micronic filter element also screens out foreign matter, and a transparent plastic bowl is provided to show level of excess water. Made by **Generant Engineering Co.**, 258-260 S. 20th St., Newark 3, N. J.

For more data circle MD-110, Page 223

Thermostatic Control

Accurate temperature control of liquids or air is provided by the FulTrol thermostatic pilot controller when used in conjunction with valves, dampers and other controls. Control is installed in any position at location where temperature is to be maintained, with its rod and tube thermal element immersed in medium being controlled. Change



in temperature at thermal element activates a small pilot valve, which in turn varies control pressure applied to a motor valve or any other final control device which governs amount of cooling or heating applied to medium under control. Temperatures in adjustable ranges from 50 to 250 F and 150 to 350 F can be controlled. Pilot valve action may be reversed. Made by **Robertshaw-Fulton Controls Co.**, Fulton Sylphon Div., P. O. Box 400, Knoxville 1, Tenn.

For more data circle MD-111, Page 223

Fractional-Hp Motors

High starting torque and simplified mounting are characteristics of line of skeleton and clutch-gear types of fractional-horsepower motors. Skeleton type are two-pole, shaded-pole motors, available in sizes from 1/500 to 1/25-hp with operating speeds of 2100 to 3500

end your quick coupling problems the QUICK-SEAL way

If you haven't seen the new Titeflex QUICK-SEAL Straight-through and Check-valve Couplings—you have a pleasant surprise coming. These new Couplings . . .

1. Are leakproof. The higher the pressure, the tighter the seal.
2. Couple and uncouple in ONE SECOND—without tools.
3. Prevent hose kinking—through their 360° swivel action.
4. Are slim, easy to handle, not awkward and bulky.
5. Have no projections to snag or bend.
6. Have heat-treated steel bearing surfaces and stainless steel ball bearings and springs for long life.
7. Are made in a variety of alloys and in many sizes up to 12" diameter. Are interchangeable in the same size.

Titeflex QUICK-SEAL Couplings are made in the following types—Straight-through, Single- and Double-Check-valves. The Straight-through type has a smooth bore for free flow without obstructions. *Write today for Titeflex QUICK-SEAL Coupling Catalog.*

Titeflex, Inc.
Industrial Products Division
508 Hendee Street
Springfield, Mass.

Titeflex
QUICK-SEAL COUPLINGS

I'm interested in the possibilities for your new Quick-Seal Hose Coupling. Send me complete catalog—no obligation of course.

Name_____

Title_____

Firm_____

Address_____

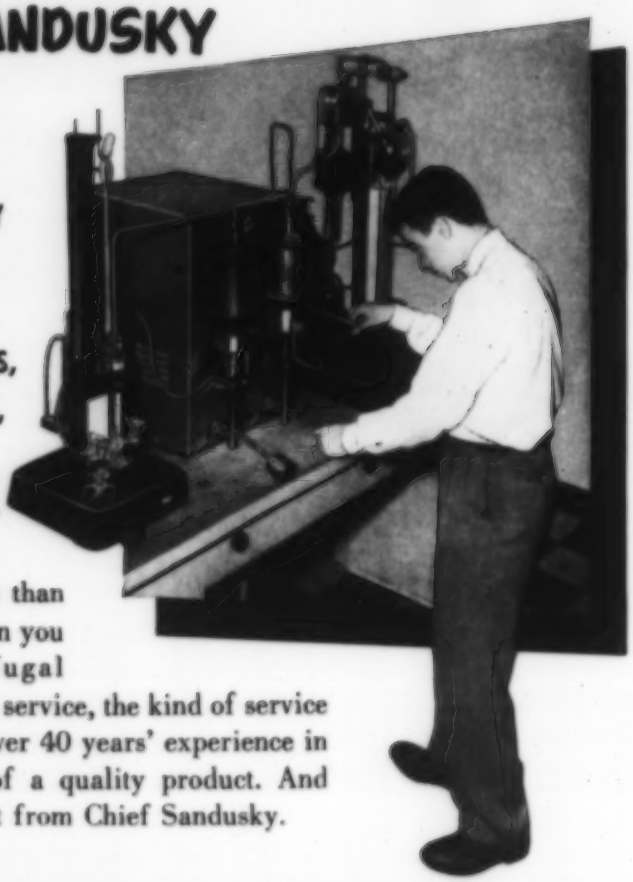
City_____ Zone____ State_____

The HIGHER the Pressure the TIGHTER the Seal

RESEARCH THAT MEANS SERVICE

CHIEF SANDUSKY

FERROUS AND
NON-FERROUS
CENTRIFUGALLY
CAST SLEEVES,
ROLLS, LINERS,
TUBES, RETORTS,
CHUTES, RINGS,
BUSHINGS,
BEARINGS, ETC.



You want more than just a product when you purchase centrifugal castings. You want service, the kind of service that's backed by over 40 years' experience in the manufacture of a quality product. And that's what you get from Chief Sandusky.

Our greatly expanded research department—enlarged in both equipment and staff—is always available to develop workable solutions to your multiple or one-of-a-kind design requirements. And with the recent addition of high-frequency induction melting furnaces, Chief Sandusky is now your logical source of supply for both ferrous and non-ferrous centrifugal castings. In addition to these services is the "plus" of practical help by field representatives or phone whenever a problem arises.

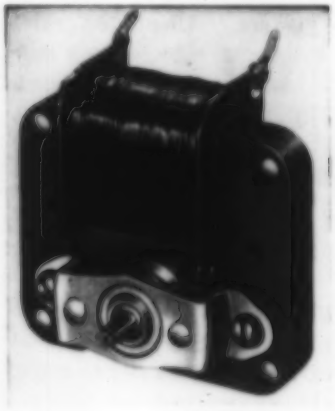
Remember, you can always count on Chief Sandusky for something extra in quality, product uniformity, and special service.

C. M. Lovsted & Co. Inc., Seattle, Wash. • Tynes Bros., Birmingham, Ala. • Cordes Bros., San Francisco and Wilmington, Calif.

SANDUSKY
FOUNDRY and MACHINE CO.

615 W. Market Street Sandusky, Ohio

New Parts



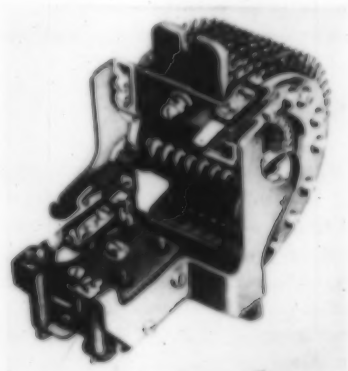
rpm. Voltage range is 6 to 220 v ac, 50 or 60 cycles. Rotation may be clockwise or counterclockwise. Maximum torque is 14 oz-in.; starting torque is 10 oz-in., shaft sizes are up to 13/64-in. diameter.

Clutch-gear type motors are of same type and voltage range. Disengagement time is about 25 milliseconds, and speeds range from 4 to 328 rpm. At 25 rpm, torque is 100 oz-in. on continuous duty, with higher torque available for intermittent use. Rotation in either direction, single or double output shafts, 3/16 to 5/16-in. shaft sizes, nylon or metal gears are other options. **Available from Comar Electric Co., 3349 Addison St., Chicago 18, Ill.**

For more data circle MD-112, Page 223

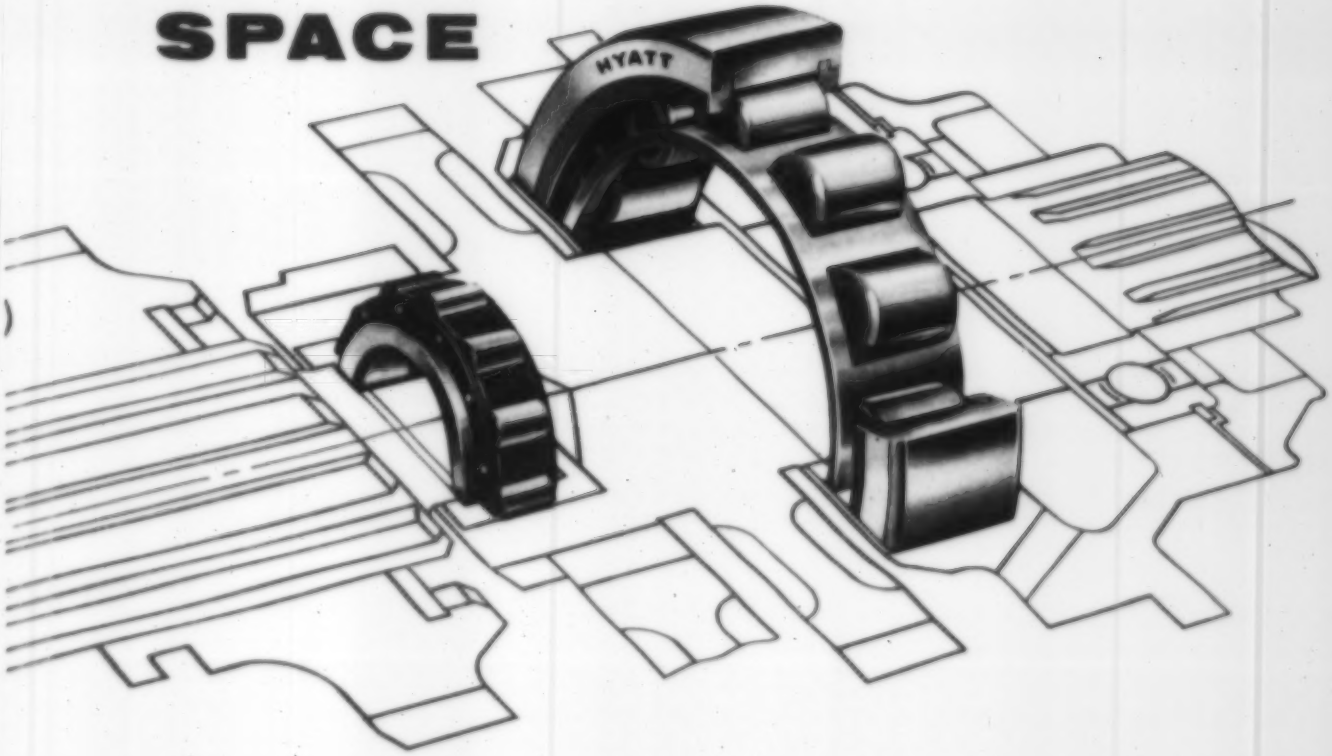
Stepping Switch

Uniselector switch is designed for heavy-duty operation extending beyond 100 million steps, impulse or self-drive. It has a stepping speed of 68 steps per second when fitted with up to five double-ended wipers. Speed averages 60 steps per second when switch is fitted with up to eight double-ended or ten



How Hy-Loads can help you

...SAVE SPACE



HY POTENUSE, the sage of the slide rule, SAYS:

your COMPLETE LINE of cylindrical roller bearings

Here's a tractor transmission where the designer's done a mighty fine job of cramming the whole works into a housing with dimensions tighter than McTavish's purse strings!

See how he did it? He used a HYATT BU-type Cylindrical Roller Bearing at the pilot position with the *outer race omitted.* Then on the input shaft he used a HYATT TS-type bearing with the *inner race omitted.* Gear-box size is held to a minimum with maximum bearing capacity! Hyatt makes 4 types of Hy-Loads with separable inner races and 2 types with separable outer races. And brother, they sure come in handy when you're cramped for space! If you haven't a HYATT General Catalog No. 150 handy, better send for yours right now. It'll help you find the answer to lots of pesky problems. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS

STRAIGHT BARREL TAPER

AVON Fusionweld STEEL TUBING

IT'S TOUGHER • MORE DUCTILE • SMOOTHER • MORE ECONOMICAL TO FABRICATE

IS TOUGHER . . . Avon's own exclusive high frequency resistance welding method produces an entirely new uniformity of grain structure in the welded and adjacent wall area by means of an advanced type of electronic control. This exclusive process combined with our improved cold drawing of larger size tubing into smaller diameters is responsible for the extremely smooth surface finish, closer diameter tolerances and new ease of fabricating.

HAS A PERFECTED SINGLE WALL CONSTRUCTION . . . Avon is able to offer thin wall tubing as a highly impressive substitute for costlier tubing—both ferrous and non-ferrous—because of its hi-cycle method of controlled welding. This tubing is available in three tempers—"as welded," "as drawn" and annealed to insure the last word in adaptability to varied tubing uses. It is more economically fabricated—takes tougher bends, beads, flares, etc.—withstands pressures up to 18,000 PSI—has no equal in resisting the severest types of fatigue from vibration.

IS EASIER TO FABRICATE . . . Avon's exclusive tube making process has proved itself, matching the most difficult forming operations, with a higher degree of ductility and tensile strength to insure new fabricating ease, lower scrap loss, greater performance reliability. Today our mills are successfully producing over 7½ million feet per month for hundreds of important tubing applications. Our sales engineering staff will gladly assist you . . . or send us your blue prints for tube quotations.

•

⅜" O.D. to ¾" O.D.
PLAIN OR TERNE COATED

AVON TUBE DIVISION

HIGBIE MANUFACTURING CO.

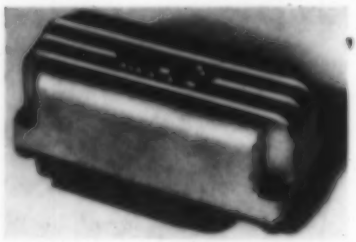
ROCHESTER MICHIGAN

single-ended wipers. Armature stroke is set by a simple adjustment of the knife-edge suspension. The interrupter springset is adjusted by setting the camber of the base plate by means of two securing screws. Bank contacts, wipers, collector rings and brushes are nickel-silver for maximum wear resistance. Mechanism is designed for use with standard 25-contact banks. A new wiper-brush assembly adapts it for use in replacing existing mechanisms. Standard range of coils covers 22, 40, 50 and 60-v dc operation. Coils can be supplied for other voltages. Available from **IMTRA Corp.**, 58 Charles St., Cambridge 41, Mass.

For more data circle MD-113, Page 223

Solenoid Air Valve

An aluminum cover completely protects both the solenoid and valve components of model 541 air valve from dust, dirt and water. Cover of this ¼-in., four-way, solenoid-operated spring-return valve



is gasket sealed with locked-in screws. The compact, lightweight unit measures 6¼ x 3¼ x 2¾ in. Made by **Mechanical Air Controls Inc.**, 10030 Capital Ave., Oak Park, Detroit 37, Mich.

For more data circle MD-114, Page 223

Pipe and Fittings

Poly-Gem flexible, lightweight plastic pipe and fittings, as well as stainless steel clamps, are available in sizes from 1 to 3 in. Polyethylene pipe resists rot, rust and electrolytic corrosion. It is made to specified diameters and wall thicknesses rather than drawn to reduced sizes, minimizing residual strain, which in turn lessens cracking and decomposi-

Carrier's Experience Proves

KLIXON
Thermo Snap®
CONTROLS

are Dependable and Service Free

Carrier Unit Heaters have long been known for their heating efficiency and outstanding performance.

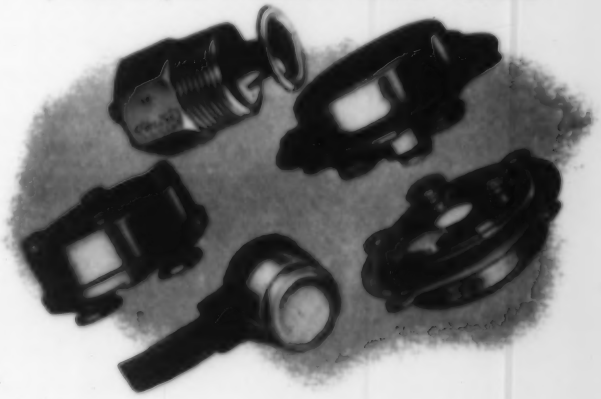
To insure accurate temperature control in their gas-fired unit heaters, Carrier uses Klixon Thermo-Snap Temperature Controls. Mr. Theodore F. Stone, Chief Product Engineer, writes: "We have used Spencer Klixon fan and limit temperature controls on our units for 6 years and have always found them to be dependable, service free and in accordance with specifications."

What's your temperature control problem . . . low and high limit controls, fuel delay switches, tube and rectifier cooling, fan switches, operating control . . . Klixon Thermo-Snap Controls are meeting the requirements for these and other applications in military and civilian products, daily.

Klixon Thermo-Snap Controls are available in many hermetically sealed and open types in a wide variety of operating temperature ranges.

Klixon Engineers, specialists in temperature control applications, can help you work out your specific application details. Write for their help or further information.

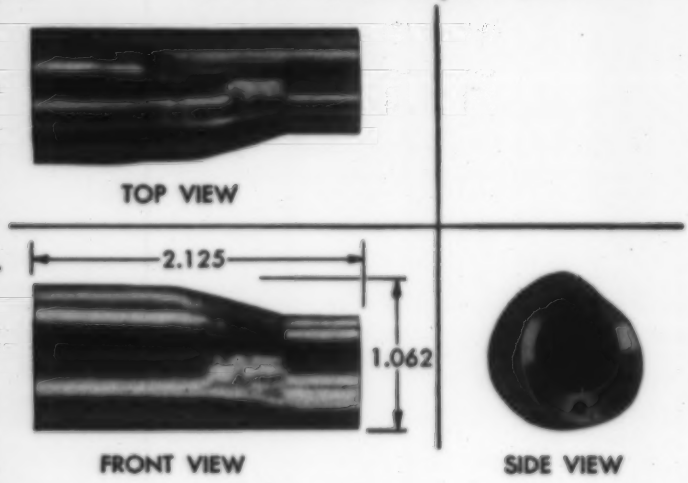
Typical Klixon Thermo-Snap Controls that can help you solve your Thermostat Control Problems



KLIXON

METALS AND CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
3203 FOREST STREET, ATTLEBORO, MASS.

This 3 Dimensional Cam Incorporates Over 1,000 Precision Dimensions!



PARKER CAMS MAKE POSSIBLE THE PERFORMANCE AND CONTROL OF SUPERHUMAN MECHANICAL FUNCTIONS

There are engineers with three dimensional cam problems who are unaware that their difficulties can be overcome—that Parker can design a single cam with an infinite number of exact stations—then reproduce thousands of absolutely identical duplicates to control relative motions through geometric and non-geometric curves in three dimensions.

Impossible performances are now daily routine through cam control in

SUPERSONIC AIRCRAFT • INSTRUMENTATION AUTOMATION • ELECTRO-MECHANICAL ENGINEERING

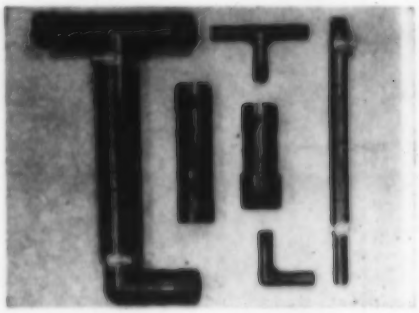
Send today for your copy of the astonishing story of a Parker-engineered cam that is the "brain center" for jet aircraft. Contact Parker for full information on how Parker cams can "think" for your machinery.

THE PARKER STAMP WORKS, INC.
CAM DIVISION
FRANKLIN AVENUE • HARTFORD, CONNECTICUT

by Parker

New Parts

tion when pipe is subjected to continued exposure to sunlight and adverse weather conditions. Resistant to acids, alkalis and metallic salts, pipe has long life in the presence of highly corrosive fluids, gases and vapors and is

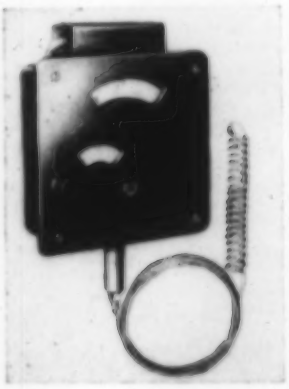


also nontoxic and resistant to the growth of bacteria and molds. It is also made in the form of twin pipes completely joined throughout its length. The joint may be cut easily for inserting clamps and attaching fittings. Made by **Acme Rubber Mfg. Co.**, Meade St., Trenton, N. J.

For more data circle MD-115, Page 223

Temperature Control

Type E32N indicating temperature control is designed for controlling and indicating temperatures of gases, liquids and hot plates. Calibrating mechanism



compensates for movement errors of commercial thermal systems, permitting replacement of these systems in the field without loss of calibration accuracy. Control point accuracy is equivalent to

that of individually calibrated units. Twelve standard models find application in incubators, water baths, mechanical convection or gravity type ovens, molding machines and laboratory testing cabinets. Range spans vary from 300 or 550 F between limits of −150 to 650 F with an on-off differential as close as 0.5 F. Standard rating is 15 amp 115 or 230 v ac; 20-amp ac and pilot duty dc ratings are available. Made by **United Electric Controls Co.**, 85 School St., Watertown 72, Mass.

For more data circle MD-116, Page 223

Dry Type Air Filter

Line of dry type Micronic air filters is designed for rigors of truck, bus and tractor operation; fleet service; marine power and stationary service. Filter element of resin impregnated, convoluted

cellulose provides filtration efficiencies over 99 per cent with airborne particles of all sizes, regardless of engine speed. Particles as small as 1 micron are removed from air. Manifold mounted type AF-100 for updraft is intended for triple or dual mounting on diesel engines or single mounting on gasoline engines. Hat type AF-200 for down-draft is usually single mounted on gasoline engines up to 150 hp, while outside cowl mounted type AF-400 is single mounted on gasoline or diesel engines up to 200 hp. Filter is easy to service and clean. Made by **Purolator Products Inc.**, 970 New Brunswick Ave., Rahway, N. J.

For more data circle MD-117, Page 223

POWDER METALLURGY can duplicate this part for

61% LESS

MACHINED PART — 18¢
POWDERMET* PART — 7¢

Don't cut parts—Cut Costs!
—with YALE Powdered Metal Parts

When it comes to keeping production costs down, American industry turns more and more to powder metallurgy. For here are tough, accurate parts completely ready for assembly...that not only do the job more cheaply, but often *better!*

With identical machined parts, most of the cost goes into the expensive machining operation. The price of *one* machined part will buy up to *six* of the same parts in powdered metal!

Close tolerances, excellent wearability, and controlled porosity are established Powdermet* virtues. Special properties—such as self-lubrication, or unusual electrical characteristics—can also be achieved. Alloys are available exceeding the tensile strength of mild steel.

The answer to your production problems may well be Powdermet* parts... and Yale & Towne. For Yale & Towne has the experience and know-how to serve you best in this rapidly-developing new field.

A qualified Yale & Towne engineer is available to discuss the advantages and limitations of powdered metal parts—*right in your own plant!* He will show you how powder metallurgy may cut costs in *your* production operations. There is no obligation for this engineering counsel.

YALE & TOWNE

THE YALE & TOWNE MANUFACTURING CO
Powdered Metal Products Division
9335 BELMONT AVE. • FRANKLIN PARK, ILL.

TYPICAL PM PARTS

Filters	Gears
Bearings	Cams
Switch Parts	Keys
Wheels	Valves
Sprockets	Ratchets
Pawls	*And many more*

Get your copy of this informative new booklet now!

*Registered Trade Mark

—Send Today For Free Booklet—

The Yale & Towne Manufacturing Company
Powdered Metal Products Division
9335 West Belmont Avenue
Franklin Park, Illinois

☐ Send Booklet ☐ Send information on PM parts for attached specifications or drawings.
☐ Have a Yale & Towne Powdered Metal engineer call on me.

Name.....Title.....
Company.....
Address.....
City.....Zone.....State.....

CALL ON R/M ENGINEERING SERVICE

CONDOR WHIPCORD ENDLESS BELTS FOR DESIGN VERSATILITY

Machine designers find Condor Whipcord the ideal endless belt for wood planers, saws, crushing-screening machines and textile machinery—wherever a serpentine drive supplies the power for several operations. A highly flexible belt, it is specially engineered for drive designs where pulleys are small, speeds high, centers short, tensions high, or take-ups small.

Condor Whipcord Belt is pre-stretched during manufacture to eliminate length variation and inelastic stretch on the job. It is practically unaffected by moisture or atmospheric change. R/M's exclusive Extensible-Tip "rubber-rivets" the cover-end of the belt so it cannot separate under tension while rounding pulleys. On many drives, Condor Whipcord Belts with Extensible-Tip have outlasted ordinary belts 3 to 10 times.

If your design calls for a general-purpose transmission belt or if you have a troublesome belt drive problem, make it a point to discuss your requirements with an R/M specialist. Whatever your design needs—transmission belts, hose, conveyor or V-belts, or molded rubber products—let R/M specialists work with you.

For booklet shown, or other data, write, phone or wire:

MANHATTAN RUBBER DIVISION
Raybestos-Manhattan, Inc.
Passaic, N.J.
Gregory 3-2000

R/M

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METALS, ENGINEERED PLASTICS

Brake Blocks, Linings and Clutch Facings

Fan Belts and Radiator Hose

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

FOR HELP IN SOLVING YOUR PROBLEMS

SINTERED METAL Friction Parts

Have a friction problem where high temperatures or close tolerances are factors? R/M Sintered Metal Friction Parts may be your answer. Under such severe conditions, R/M Sintered Metals will perform without appreciable increase in wear rate because of their high thermal conductivity and absence of destructible bond. Remember, unlike most manufacturers, R/M works with all kinds of friction materials. So whatever your friction requirements, you can be sure of completely unbiased advice when you consult Raybestos-Manhattan.

Write for your copy of R/M Bulletin No. 500. It's loaded with practical design and engineering data on all R/M friction materials.

EQUIPMENT SALES DIVISION
Raybestos-Manhattan, Inc.
6010 Northwest Highway
Chicago 31, Ill.
ROdney 3-2400

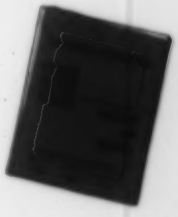
PACKINGS, GASKETS, Asbestos Textiles and "TEFLON"* products

R/M makes packings and gaskets for every conceivable application. They are used wherever it is necessary to seal against air, gas, water, steam, oil, chemicals, solvents, food products, and hydraulic fluids. R/M also makes a wide range of "Teflon" products and a great variety of asbestos textiles. If you have a problem in design or manufacture that any of these products might solve, don't hesitate to call on R/M's specialized engineering service for advice.

**Du Pont's trade-mark for its tetrafluoroethylene resin*

For booklet shown, or other data, write, phone or wire:

PACKING DIVISION OR ASBESTOS TEXTILE DIVISION
Raybestos-Manhattan, Inc.
Manheim, Pa.
Manheim 5-2211



RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • No. Charleston, S.C. • Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Conveyor Belts

Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

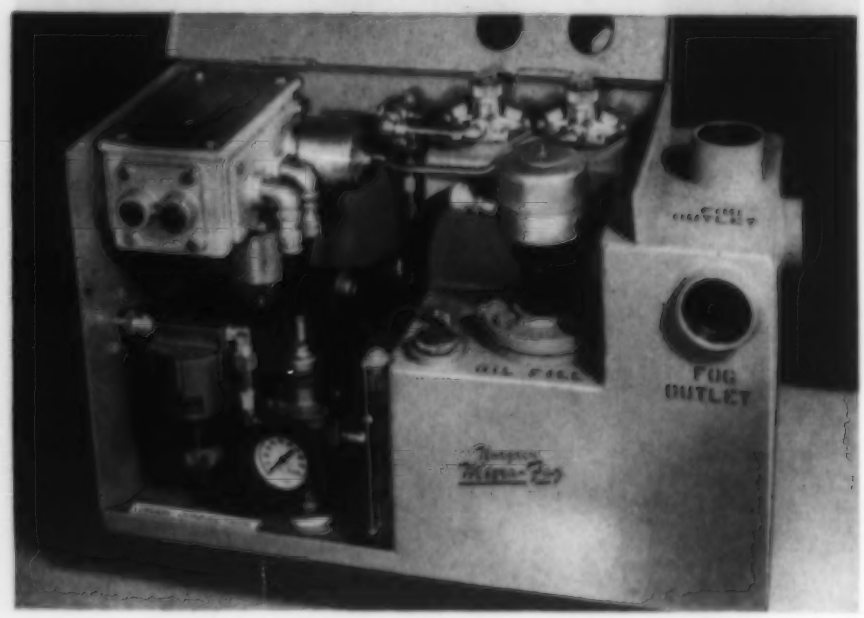
Asbestos Textiles

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

R/M

Norgren Automatic-Drain Filter in Micro-Fog Lubro-Control Unit



New Lubro-Control model 33AB-4 lubricates up to 1000 bearing inches.

provides vital bearing protection automatically

prevents contamination of oil supply...

- **assures clean, dry air...removes grit, pipe scale and moisture from the air line**
- **drains automatically. Operates independently of air pressure fluctuation and air flow**

The unit shown above is a new development by Norgren...a large capacity Micro-Fog Lubro-Control Unit which provides centralized, *automatic* multi-bearing lubrication up to 1000 bearing inches. Two of these units on a large Cross Transfer-Matic (photo, right) in an automobile plant lubricate 350 ball bearings and 170 spur gears. The Norgren Automatic-Drain Filter is a vital part of this unit.

Filtering air that powers your tools, cylinders and other pneumatic equipment is essential for top equipment performance and low maintenance costs. Hundreds of users have proved the high efficiency of Norgren Automatic-Drain Filters. For complete data..

C. A. Norgren CO.
3442 So. Elati, Englewood, Colo.

...WRITE FOR CATALOG SHEET 3-6

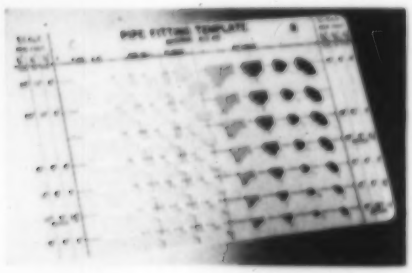
Oil Fog Lubricators • Pressure Regulators • Air Filters • Valves • Hose Assemblies

ENGINEERING DEPARTMENT

EQUIPMENT

Pipe Fitting Template

Designed for layout and detail drawings of piping systems, No. 49 pipe fitting template utilizes the double line principle. Perspective views are made by using the ellipses for the different sizes of pipe, bell and flange diameters.

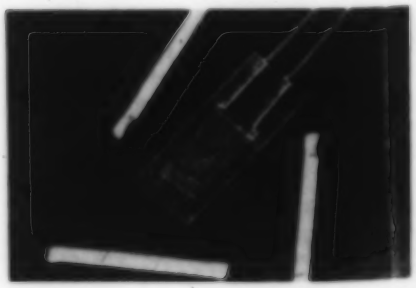


Six different scales are provided, each with six sizes of piping ranging from 24-in. pipe diameter in ⅛-in. per ft scale to 1¼-in. pipe diameter in ¾-in. per ft scale. Made of 0.030-in. matte finish plastic, the template has smooth cutouts. Allowance is made for pencil to assure accuracy. Size of template is 8 x 5⅛ in. Made by **Rapidesign Inc.**, P.O. Box 592, Glendale, Calif.

For more data circle MD-118, Page 223

Resistance Thermometer

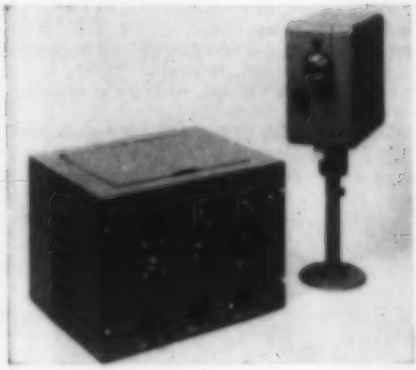
Silicone-impregnated glass fiber used in SN-1 resistance thermometer elements permits continuous operation at 500 F and short-term use at 600 F. In common with



other RdF Stikon elements, a temperature-sensitive grid of very fine nickel wire is bonded between two paper-thin wafers of insulating material. Attached by appropriate cements to almost any surface anywhere, element is unaffected by shock or vibration and is accurate and quick-indicating. It is only 0.010-in. thick by 9/16 x 1 7/16 in. and weighs less than 1/200-oz. At 70 F, resistance is 100 ohms. Made by **Ruge-de Forest Inc.**, 50 Moulton St., Cambridge 38, Mass.

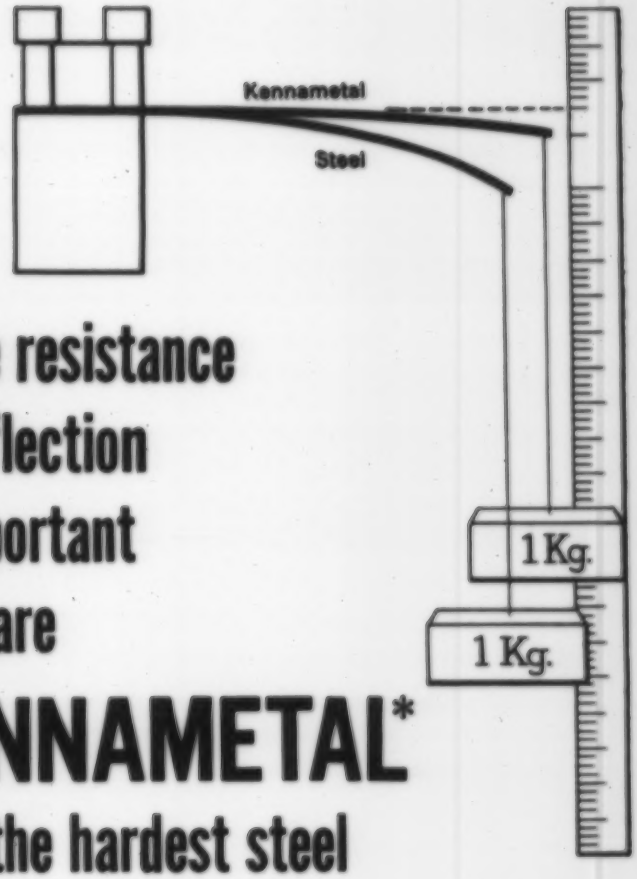
For more data circle MD-119, Page 223

Surveillance Unit



Consisting of an electrically driven camera and a separate timing device, this surveillance unit can be used to make a record of gage readings, meter readings and readings of other engineering test equipment. The 6 x 6 x 3½-in. camera can be mounted adjacent to the area or instruments or meters to be photographed. It uses 16-mm film and holds a 100-ft roll, providing 4000 frames or pictures. Timing unit, which measures 10 x 8 x 7 in. and is connected to the camera by a four-conductor cable, causes the camera to take single frames or photographs at specific time intervals. One of two separate timing devices is a program type electric time clock which provides for setting the unit to begin operation at any predetermined time of the day or any day of the week. The second timer is energized by the program clock and controls the camera. In the standard unit, this timer provides 2, 4, 8, 16, 20 or 100 frames

(Continued on Page 296)



where resistance to deflection is important compare

KENNAMETAL*

with the hardest steel

In mechanical devices, deflection of parts under load is always a problem. Consequently, one of the most important measures of serviceability of any material is its Young's Modulus of Elasticity . . . the extent to which the material will deflect under load.

Compare, for instance, the Young's Modulus of Elasticity of the hardest known alloy steels with that of Kennametal. Steel has a YME of approximately 30 million p.s.i., compared to Kennametal's 90 million. Under a given load, Kennametal will deform only ⅓ as much as steel. Or, to reach the same degree of deflection, you can load a Kennametal part from two to three times as much as the part made of steel.

This characteristic of Kennametal, in addition to its extreme hardness, high strength and resistance to corrosion and abrasion, is being used to great advantage in a variety of applications. *Why not put it to work for you?* For additional information and a copy of Bulletin C-53, write: KENNAMETAL INC., Latrobe, Pennsylvania.

**Kennametal is the registered trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum.*

INDUSTRY AND KENNAMETAL ...Partners in Progress

General Electric—one source of supply

MAGNETIC CONTACTORS AND STARTERS

Select from a full line of open and enclosed devices—from fractional hp through 200 hp (600 volts, maximum). Available in every popular NEMA enclosure, including: general-purpose; semi-dust-tight; water-tight; dust-tight; explosion-proof; oil-immersed, corrosion-resistant; and JIC (automotive).

COMPLETE LINE OF MODIFICATIONS is offered on magnetic starters such as: push button or selector switch in cover, extra interlocks, third pole overload relays, separate a-c control circuit, and extra control relays.

1. **FULL-VOLTAGE MAGNETIC STARTERS** (CR7006) for squirrel-cage induction motors are available in size 00 to size 5 with bi-metallic overload protection.
2. **REVERSING CONTROLLER** (CR7009) combines two standard magnetic starters and mechanical interlock.
3. **MULTI-SPEED CONTROLLER** (CR7107) is ideal for full-voltage starting of 2-, 3-, or 4-speed squirrel-cage motors.
4. **COMBINATION STARTERS** (CR7008) provide disconnecting means and short-circuit protection by nonfusible or fusible disconnect, or circuit breaker.
5. **CONTACTORS AND MULTI-CIRCUIT CONTROL RELAYS** (CR2810 and CR2820) will handle loads from 5 to 240 amps.

PUSH BUTTONS, SELECTOR SWITCHES, INDICATING LIGHTS

STANDARD-DUTY PUSH-BUTTON STATIONS

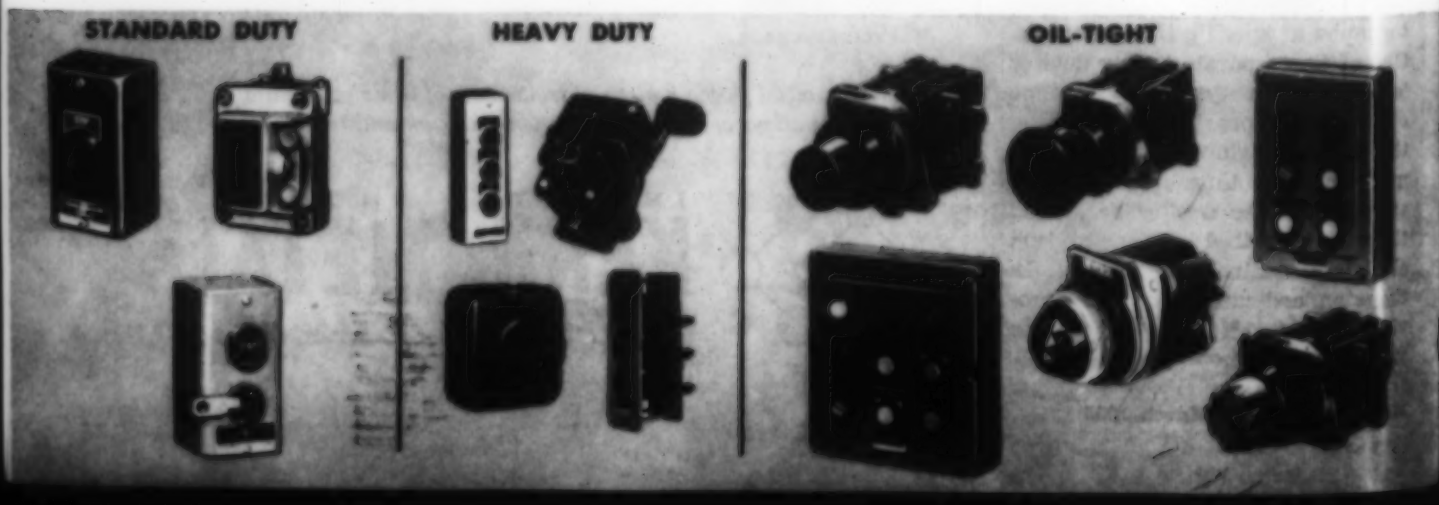
(CR2943). Stations are available with 1, 2, or 3 buttons and in pendant form. Double-break silver contacts assure reliable operation. Units are back-mounted on cover and need not be removed for wiring.

HEAVY-DUTY PUSH-BUTTON STATIONS

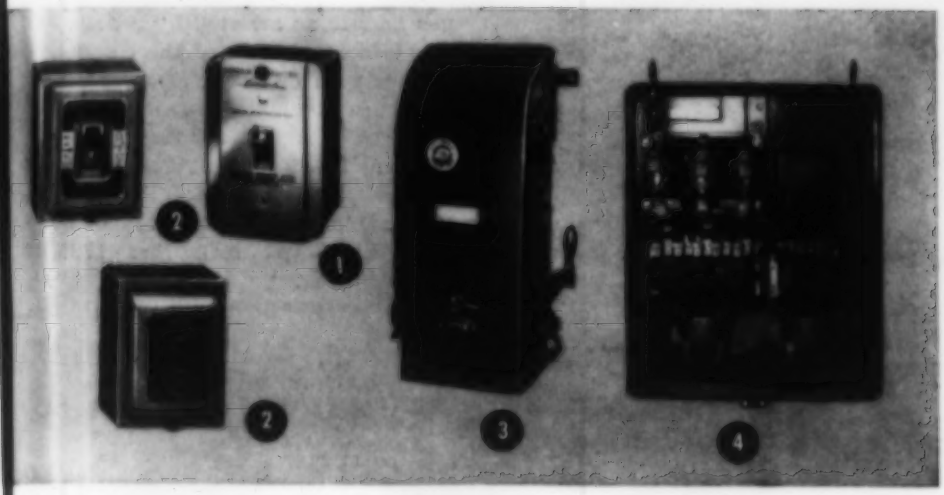
(CR2940). Stations offer wide variety of 1- to 6-unit combinations of push buttons, selector switches, and indicating lights. Also furnished for flush mounting. Palm-, foot- and treadle-operated stations available.

OIL-TIGHT PUSH-BUTTON UNITS AND STATIONS

(CR2940). Units have building-block design permitting any combination of contact arrangements. Also available are indicating lights and selector switches. Enclosures accommodate 1 to 16 units.



for all your general-purpose control



MANUAL AND REDUCED VOLTAGE STARTERS

1. **FRACTIONAL HORSEPOWER MANUAL STARTERS** (CR1061) are small-size, across-the-line starters operated by toggle switch—includes accurate bi-metallic overload protection.

2. **MANUAL STARTER UP TO 7½ HP** (CR1062) has snap-action toggle switch or push-button operator which trips free on overload. Available in 2-, 3-, or 4-pole forms.

3. **MANUAL REDUCED-VOLTAGE STARTERS** (CR1034) are autotransformer types used where reduced starting currents or limited starting torques are needed. Undervoltage protection prevents automatic restart in event of power failure.

4. **MAGNETIC REDUCED-VOLTAGE STARTERS** (CR7051, CR7056) are autotransformer or resistor types designed for remote or automatic reduced-voltage starting. Timing relay provides proper timing for step-starting, eliminating excessive motor inrush currents.

General-Purpose Relay. (CR2790). For control circuit applications. Small in size with extremely long life. Rated 10 amps continuous (left).

Solenoids (CR9500). New strongbox solenoid provides firmly anchored terminal and lead type connections in a single unit. 22% smaller units mount five different ways. Complete rating coverage in push and pull, 24 to 600 volts, 25 to 60 cycles and d-c (right).

Plugging Switch (CR2962). A pilot circuit device used in conjunction with reversing magnetic starter to automatically apply and remove plugging power for quick stopping of a motor.

Pressure Switches (CR2927). A pilot device used to handle small motors directly or in conjunction with a magnetic starter for starting and stopping pressure generating equipment.

Float Switches (CR2931). Used in conjunction with a magnetic starter to start and stop small a-c and d-c motors. Float and counterweight may be interchanged for tank or sump operation.

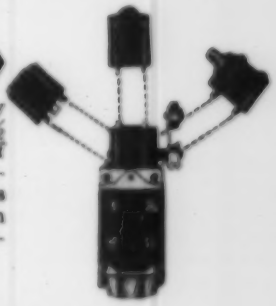
LIMIT SWITCHES

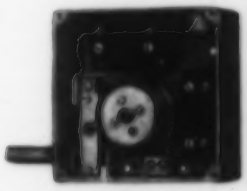
LEVER OR ROTATING TYPE

Double Circuit Lever Type (CR9440D). Snap action contacts can be changed from normally open to normally closed or vice versa. In open or oil-proof enclosed forms.

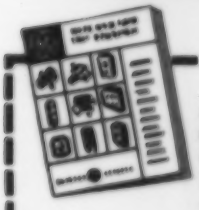
Snap-Action Lever Type (CR9440J). Used for heavy make-and-break requirements. Forms are available adjustable through 360 degrees. Operating lever firmly attached to shaft by double set of splines.

Small Snap-Action Oil-Tight (CR9440K). Only 1¼ and 1½ by 4½ inches. Oil-proof switch has 4 interchangeable heads that can face in any of four directions.





Rotating Cam Type (CR9441E) Two snap-action contact units operated through a worm gear reduction. Operating cams are easily set by adjusting only two screws.



COMPLETELY NEW CATALOG OF G-E GENERAL-PURPOSE CONTROL

Advertising and Sales Promotion Section B 734-1

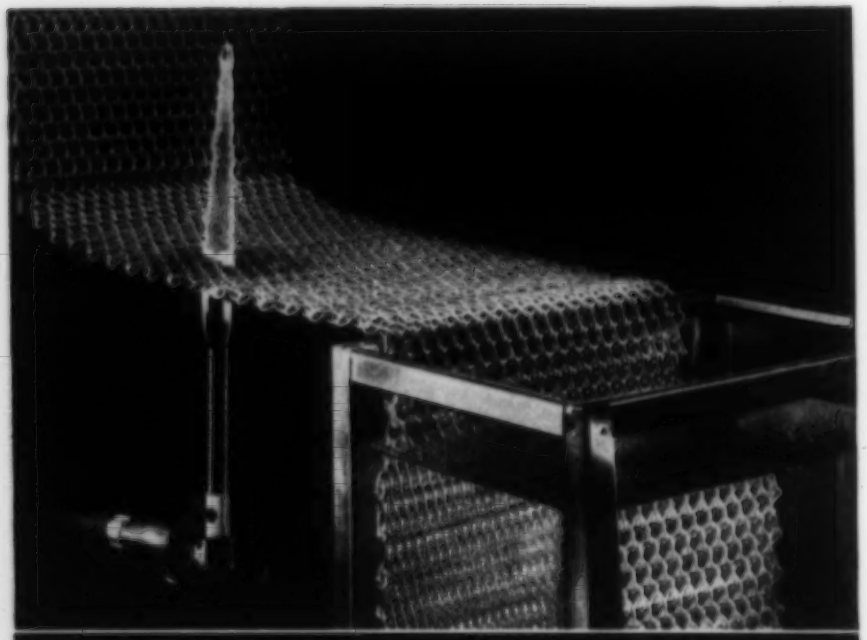
General Purpose Control Dept.
General Electric Company
Bloomington, Illinois

Please rush me a free copy of the new general-purpose control catalog, GEC-1260A.

Name .....
Title .....
Company .....
Address .....
City ..... **State** .....

For more information on any of these general-purpose controls, contact your nearest G-E Apparatus Sales Office, or distributor.

GENERAL ELECTRIC



HEATPROOF! RUSTPROOF!

Cambridge

WOVEN WIRE CONVEYOR BELTS

permit continuous heating, cleaning, washing

All-metal belt . . . corrosion resistant and impervious to damage at temperatures from sub-zero to 2100° F . . . withstands most severe conditions in heat treating, food processing, chemical manufacture, ceramic firing.

Whether you're designing machines for your own operation or for resale, you can eliminate batch handling, cut costs, provide uniform, continuous production at controlled rates of speed with moving woven wire belts.

Open mesh construction of Cambridge Woven Wire Conveyor Belts lets process atmospheres circulate freely for uniform cooling, heating, drying . . . provides flash drainage of solutions for rapid washing, quenching, cleaning, draining. Cambridge belts have no seams, lacers or fasteners to wear more rapidly than the body of the belt . . . no localized weakening.

No matter how you look at it, CAMBRIDGE Woven Wire Conveyor Belts are invaluable aids to AUTOMATION . . . help beat your biggest competition, COST. They are made in any size, mesh or weave, from any metal or alloy. Special raised edges, cross-mounted flights and other surface attachments are available to hold your product during movement.

Call in your Cambridge Field Engineer to discuss how you can cut ultimate costs by continuous operation. You can rely on his advice. Write direct or look under "BELTING, Mechanical" in your classified phone book.

CONTINUOUS QUENCHING—of small or large parts on a Cambridge belt is faster and cheaper.

ASK FOR FREE 130-PAGE REFERENCE MANUAL illustrating and describing woven wire conveyor belts. Gives mesh specifications, design information and metallurgical data.

The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

DEPARTMENT N, CAMBRIDGE 3, MARYLAND

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

Engineering Equipment

(*Continued from Page* 293)

per minute as selected by a rotary switch on the front of the cabinet. Timers with different interval settings are available to suit specific work. A braking device incorporated in the timing unit stops the camera shutter at exactly the same spot after each frame. Made by **Pho-Tect Corp.**, P.O. Box 1725, Houston, Tex.

For more data circle MD-120, Page 223

Drafting Tables

Thriftmaster drafting tables have heavy-gage steel bases with smooth-bottomed legs. They are reinforced throughout and electrically welded for rigidity. Drawing surface is selected soft wood with

zinc-plated steel cleats. Top may be tilted at any desired working angle. Tables are available with both tool drawer and another shallow drawer, with tool drawer only, or without drawers. Made by **Stacor Equipment Co.**, 768 E. New York Ave., Brooklyn 3, N. Y.

For more data circle MD-121, Page 223

Project Schedule

Produc-Trol board is an aid in planning engineering projects and in utilizing engineers' time to the best advantage. It tells at a glance how close to completion each project is and if it is on schedule; how many and which jobs various engineers are doing; and indicates rescheduling which must be done when engineers are reassigned. **Wassell Organization Inc.**, 11 Sylvan Rd., Westport, Conn.

For more data circle MD-122, Page 223

From Vacuum Melting—improved alloys with exceptional properties.

. . . *higher* PRODUCTION YIELD, *for example*

The greater purity and uniformity of vacuum-melted metals means substantially higher production yields in your plant . . . fewer inspection rejects. In ball bearing manufacture, for example, inspection loss was cut from 50% to 3% when vacuum-melted metals were used.

That's because vacuum-melted metals are free of nonmetallic inclusions . . . better physically . . . closer to their theoretical limits of performance. For in vacuum melting, gaseous impurities are literally sucked from the molten metal. Composition limits are more closely held . . . fabrication characteristics improved.

Vacuum Metals Corporation, pioneer in development and leading producer of vacuum-melted metals, now has them available in tool, high-speed, stainless and alloy steels – in most sizes and grades – as well as special ferrous and nonferrous alloys. If you have a metals problem that vacuum-melted alloys might solve, please describe it in as much detail as possible. Write *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, N. Y.*

VMC

VACUUM METALS CORPORATION

Jointly owned by Crucible Steel Company of America and National Research Corporation

Everyone recognizes this as a sign of going places . . .

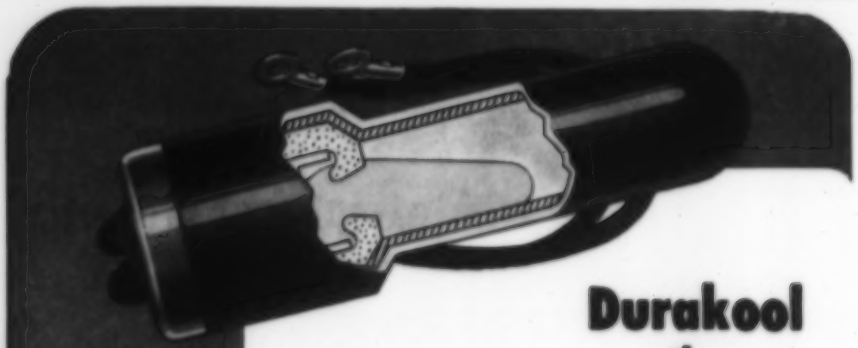
And smart gear users know this CINTI is the sign of the best in gears made to your specifications.

May We Send You Our Brochure?

CINTI ®

"Gears...Good Gears Only"

THE CINCINNATI GEAR CO. • CINCINNATI 27, OHIO



Durakool the STANDARD OF QUALITY, DURABILITY AND LIFE

WITHSTANDS HIGH TEMPERATURES

Years of trouble-free performance on the most difficult of assignments have won top recognition for Durakool Mercury Tilt Switches. High temperatures, fast cycling and 24 hour schedules taken in stride. 7 sizes, 1 to 65 amperes. Send for Bulletin 525.

See telephone directory for local distributor or write
DURAKOOL, INC. — Elkhart, Indiana

Durakool ALL-STEEL MERCURY *Switches*

THE ENGINEER'S Library

Recent Books

Principles of Experimental Stress Analysis. *By Mark B. Moore, associate professor of mechanical engineering, Rutgers University;* **158** *pages,* **5½** *by* **8½** *inches, clothbound; published by Prentice-Hall Inc., New York; available from* MACHINE DESIGN, **$4.00** *postpaid.*

This textbook develops basic principles used in modern stress analysis, emphasizing the use of electric strain gages. In 13 chapters, it covers basic stress-strain relationships; failure of engineering materials; mechanical, optical and electric strain gages; strain in two directions; strain gage forms; dynamic strain measurement; brittle coatings; photoelastic strain measurements; and the membrane analogy. The last chapter presents a series of experiments dealing with causes of failure and various types of strain measurements.

Strong emphasis is placed on prevention of failure of engineering structures and machines by proper experimental stress analysis. Use of mathematics is kept to a minimum.

•

Control-System Dynamics. *By Walter R. Evans, systems group leader, electromechanical engineering department, North American Aviation Inc.;* **296** *pages,* **6** *by* **9** *inches, clothbound; published by McGraw-Hill Book Co. Inc., New York; available from* MACHINE DESIGN, **$7.00** *postpaid.*

This reference and textbook exemplifies techniques for determining response of linear control systems. It presents calculation procedures to aid in analyzing and selecting control systems for desired response.

The first seven chapters cover dynamics, typical components, transient response, transfer functions, frequency-response method

UNIVERSALLY USED*

Compact Low-Cost SKINNER Solenoid Valve for Thousands of General Service Applications

No other valve can match the utility and economy offered by the Skinner V5 (Universal) Valve. It is Underwriter approved for all-purpose service, and is suitable for all common media. Its applications are virtually unlimited, and include use on aircraft, automotive, chemical, dental, refrigeration, drink dispensing, heating, industrial, pilot and process control, and instrumentation equipment.

Valves of this series give fast dependable operation — *through* [redacted] They are direct acting, spring loaded, *leakproof* . . . and perform perfectly in any position, in ambient temperatures from minus 250°F. to plus 450°F. Available in a broad selection of types, electrical outlets, port locations and sizes, flow adjustments and coil types.

Also available with "Quick Exhaust" for extra fast cylinder return.

Media — Air, gasoline, inert gases, kerosene, oils, water, steam and many semi-corrosive media.

Pressure Rating — 0-1000 p.s.i.

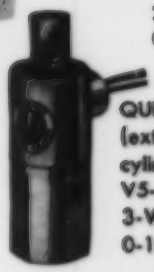
Construction — Leakproof sealing, bubble-tight shut-off at all ports; packless, frictionless construction; stainless steel internal parts; moisture-resistant, varnish-impregnated coils.

Specifications — *Type* — Two- or three-way, normally open or normally closed, or with directional control.
Duty Cycle — Continuous or intermittent.
Orifice Diameters — 3/64" to 1/4"
Pipe Size — 1/8" or 1/4" NPT.
Voltage — all common AC and DC voltages.
Power Consumption — 10 watts.

Do you have a valve problem? Ask us for the services of a specially trained Skinner resident engineer — he'll tackle your problem immediately.

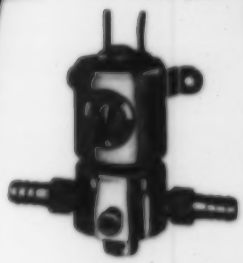
GENERAL SERVICE & VACUUM
V5 Series
2- & 3-Way
0-1000 p.s.i.

MINIATURE CUT-OFF
V2 Series
2-Way
0-250 p.s.i.



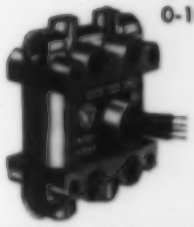
QUICK EXHAUST
(extra fast cylinder return)
V5-3 Series
3-Way
0-150 p.s.i.

HI-PRESSURE HYDRAULIC
V10 Series
2- & 3-Way
0-1000 p.s.i.

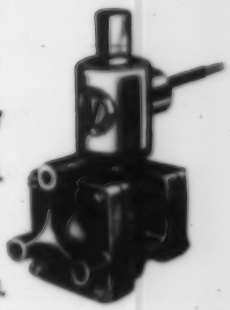


SANITARY
V4 Series
2-Way
0-20 p.s.i.

EXPLOSION-PROOF
X5 Series
2- & 3-Way
0-1000 p.s.i.



ALL-PURPOSE FOUR-WAY
V9 Series
4-Way 0-150 p.s.i.



HI-FLOW INDUSTRIAL
M Series
2- & 3-Way 5-150 p.s.i.

World-Wide Representation — Immediate Delivery on Standard Valves

SKINNER SOLENOID VALVES

SKINNER ELECTRIC VALVE DIV.
The Skinner Chuck Company
115 Edgewood Avenue, New Britain, Connecticut
Please send us your bulletins on the following Skinner valves:

.....

.....

Please have a Skinner representative call on (date)

.....

Name.....

Company.....

Street.....

City.....Zone....State.....

SKINNER ELECTRIC VALVES

® THE CREST OF QUALITY

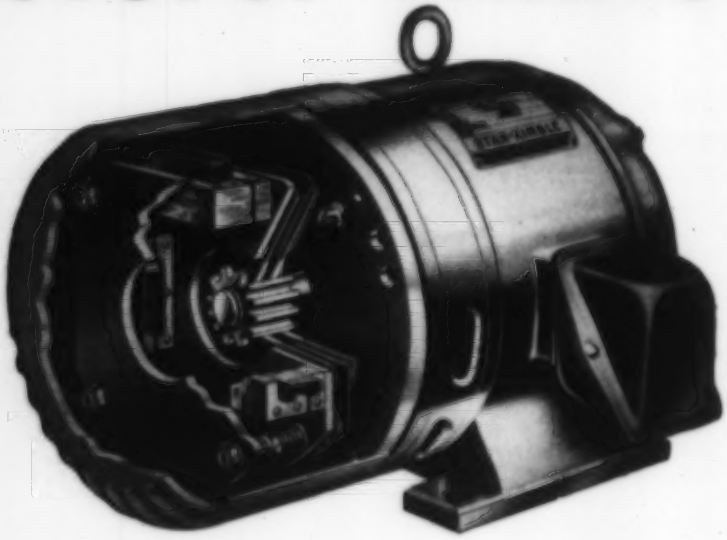
STOP! START STOP! START STOP! START STOP!

START STOP! START STOP! START STOP! START

START STOP! START STOP! START STOP! START

Instantaneous Drag-free

STOPS! STARTS



STOP! START STOP! START STOP! START STOP!

minute after minute YEAR AFTER YEAR with Star-Kimble Brakemotors

That extra-large brakelining area you see brings a Star-Kimble Brakemotor and its connected load to an *extra-fast stop*—as short as a fifth of a second from full speed to standstill if desired.

And the small air gap contributes to *equally fast starts*. Brake is released the instant motor current is switched on—equipment starts without drag.

That's the story of a *single* Star-Kimble stop-start cycle. And the experience of user after user *proves* that Star-Kimble Brakemotors *maintain* the same split-second stops, the same smooth starts, through hundreds of thousands of cycles. In reversing service, conventional plugging methods with a typical 5 hp motor allow only 3 starts per minute. With a Star-Kimble Brakemotor, the figure is boosted to 10!

Of course, every Star-Kimble Brakemotor is a compact, integral unit designed to save space—and give rugged, dependable performance. One manufacturer—one responsibility.

For the full story, write for Bulletin B-501-A

STAR-KIMBLE

MOTOR DIVISION

KIMBLE PRINTING PRESS AND MFG. CO.

201 Bloomfield Avenue Bloomfield, New Jersey

The Engineer's Library

and the root-locus method. The remaining five chapters proceed from these concepts into multiple-loop systems, circuit analysis, use of determinants, transfer functions and graphical analysis of nonlinear systems.

•

Strength of Materials. *By Joseph Marin, head, department of engineering mechanics; and John A. Sauer, head, department of physics, Pennsylvania State University;* 536 *pages,* 6 *by* 9¼ *inches, clothbound; published by The Macmillan Co., New York; available from* MACHINE DESIGN, $6.75 *postpaid.*

Now in its second edition, this textbook is intended to provide a clear account of the science of mechanics of materials and its application to design problems. Starting from simple stress systems, such as members subjected to tension, shear or bending, more complex systems are gradually developed, including statically indeterminate structures and combined stresses. Two new chapters include discussions of creep and temperature properties of materials, and experimental methods of stress analysis.

• •

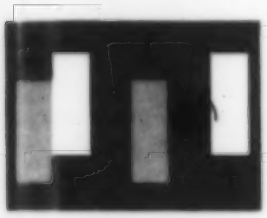
Industrial Design in America, 1954. *Edited by the Society of Industrial Designers;* 224 *pages,* 8¼ *by* 11 *inches, clothbound; published by Farrar, Straus and Co. Inc., New York; available from* MACHINE DESIGN, $12.50 *postpaid.*

Compiled by the members of the Society of Industrial Designers, this volume illustrates and describes achievements of the past year in design and development of mass-produced products for industry and home. Each example is illustrated with photographs and includes a story of the problem that faced the manufacturer and how it was solved. Nine sections deal with appearance design, better use of materials, visual selling aids, new approaches, lowering cost of manufacture, safety and health, color, product character, and convenience of use.

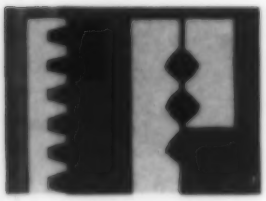
MILLING MACHINE

IN ACTUATION !

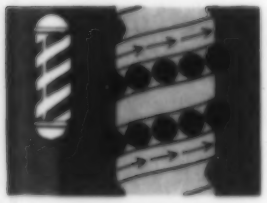
WHAT IT IS AND HOW IT WORKS:



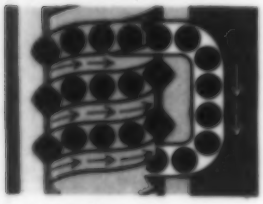
Let's start at the beginning, with the familiar principle that there's far less friction in *rolling* than in *sliding*. By applying this principle,



the *Safety ball/bearing Screw* radically increases the efficiency of rotary-to-linear motion (and vice versa). Instead of *sliding*, mating surfaces *glide* on rolling steel balls.

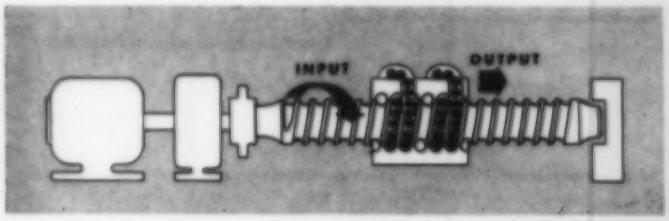


Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.



At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate while screw operates.

ADVANTAGES FOR MACHINE DESIGNERS



Compared with the conventional Acme screw's efficiency of less than 25%, that of the *Safety b/b Screw* ranges from 90% to 95%! This makes it by far the most efficient known mechanism for translating rotary-to-linear motion, or vice versa. Combined with an electrical, hydraulic or pneumatic power source, the *Safety b/b Screw* forms an actuator with tremendous advantages for the machine designer. For example, it can enable you to:

SAVE POWER—by requiring only 1/3 as much torque as the conventional Acme screw for the same amount of lineal output, and with far lower static break-away, the *Safety b/b Screw* requires much less starting and driving power. This permits the use of much smaller motors with less load on the electrical system.

ASSURE PRECISION POSITIONING—unlike some other types of actuators, the *Safety b/b Screw* permits absolute accuracy within thousandths of an inch, plus perfect synchronization of two or more movements. Where necessary, backlash can be completely eliminated by pre-loading, with only about 2% loss of efficiency.

REDUCE INSTALLATION AND OPERATING COSTS—the *Safety b/b Screw* permits significant savings in the form of smaller motors, less auxiliary equipment and less power consumption. It also assures less maintenance and longer life because its "Gothic arch"-shaped races greatly decrease dirt sensitivity, and wear due to friction is negligible.

ANY SIZE FROM 1½ IN. TO 39½ FT. IN LENGTH

Every *Safety b/b Screw* is individually engineered for its particular application. Our engineers are eager to help solve your actuator problems *now*.

MAIL COUPON TODAY FOR YOUR ENGINEERING DATA BOOK

(or see our section in Sweet's Product Design File)

Saginaw Steering Gear Div.,
General Motors Corp.
Dept. 3H, Saginaw, Michigan
Please send your Engineering Data Book to:

Name—Title_____

Firm_____

Address_____

City_____ Zone____ State_____

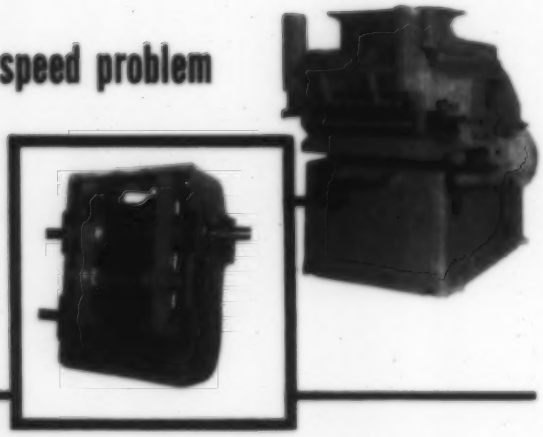
Safety ball/bearing Screw by Saginaw

Another variable-speed problem

SOLVED

by

LEWELLEN



Famous Baker-Perkins Dough Divider maintains accuracy regardless of production demands

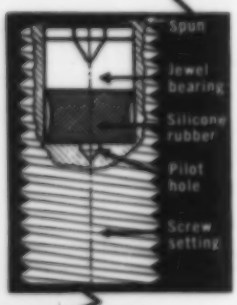
Space limitations in this particular application of variable-speed control required our use of oversized parts to meet power demands. Special problems like this one are not unusual for Lewellen. We've been solving them for more than 50 years.

If a new production machine is "on your drawing board" or if your present equipment is minus the flexibility of modern variable-speed control, let us help you. Phone, wire, or write today!

LEWELLEN

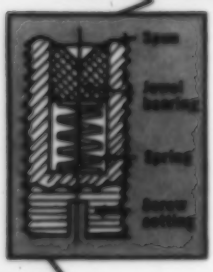
LEWELLEN MANUFACTURING CO.
COLUMBUS, INDIANA

Be SURE of SHOCK PROTECTION for delicate instrumentation



Pennies invested
Thousands saved

Bird jewels with resilient silicone rubber or spring cushions provide inexpensive shock resistance for any instrument. Bird provides variable cushioning to suit different operating conditions; mountings to any specification; controlled movement of jewel.



Bird Cushion Jewel Assemblies add the necessary safety factor to your instrument production, eliminating waste and tear-down because of poor judgment in bearing adjustment.

Let actual tests prove the superb performance of Bird Cushion Jewel Assemblies. Send specifications and sizes of jewel bearings you require. Bird will send you samples for testing in your own plant. Bird engineers are available for all your small bearing problems.

Over 40 years of serving industry with Quality jewel bearings

Richard H. Bird & Co., Inc.

Sapphire and glass jewels Precision glass grinding Jewel mounting and assembly Sapphire stylii
20 Spruce Street, Waltham 54, Mass.

The Engineer's Library

(*Concluded from Page 303*)

pendix contains very-short-time rupture data for several of the alloys, and chemical compositions for approximately 100 super-strength alloys.

Manufacturers' Publications

TIC Potentiometer Handbook. *207 pages, 5½ by 8½ inches, ringbound, paper covered; available from Technology Instrument Corp., 531 Main St., Acton, Mass., $2.00 per copy.*

This handbook presents a detailed treatment of many phases of potentiometer theory, design, performance and application. It is intended to be helpful for those who specify potentiometers for general circuit applications, analog computers and control systems.

Government Publications

Thermal Conductivity of Metals and Alloys at Low Temperatures. *By Robert L. Powell and William A. Blanpied; 72 pages, 8 by 10¼ inches, paperbound; available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., 50 cents per copy.*

This booklet, National Bureau of Standards Circular 556, is a compilation of data on thermal conductivity at low temperatures given in the extensive literature on the subject. It consists largely of tables and graphs listing various materials and their conductivities.

•

NACA Technical Series. *Each publication is 8 by 10½ inches, paperbound, side-stapled; copies available from National Advisory Committee for Aeronautics, 1924 F St., N.W., Washington 25, D. C.*

The following Technical Notes are available:

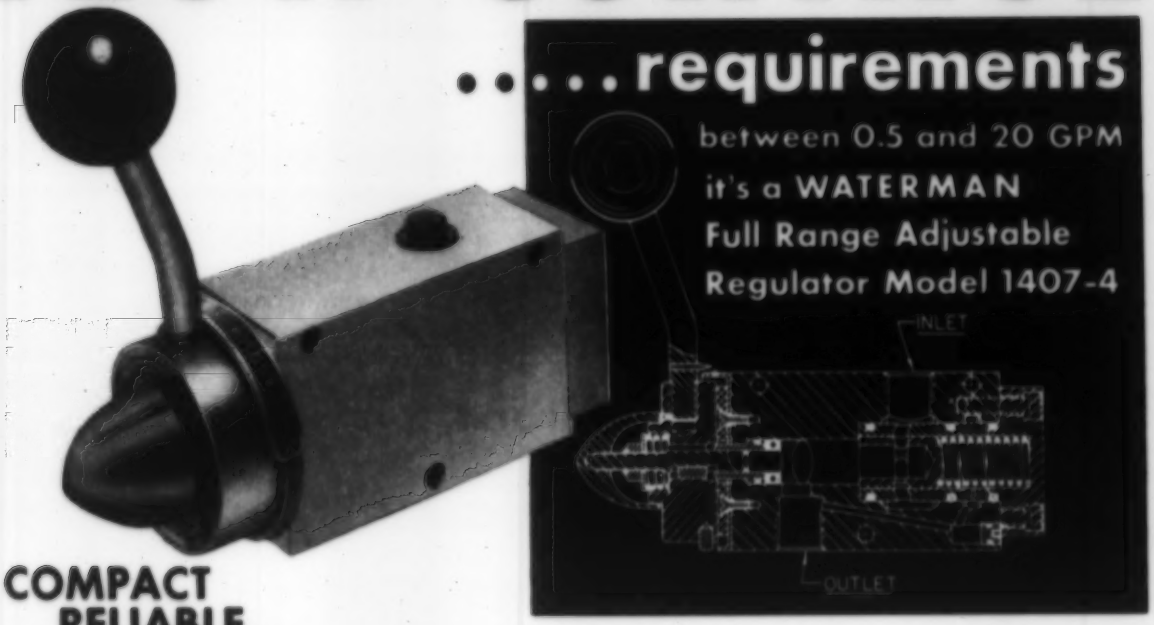
3315. **Tensile and Compressive Stress-Strain Properties of Some High-Strength Sheet Alloys at Elevated Temperatures**—32 pages.

3334. **Friction of Possible Solid Lubricants with Various Crystal Structures**—32 pages.

3337. **Investigation of Temperature Limitation of Various Lubricants for High-Temperature 30-Millimeter-Bore Ball Bearings** — 31 pages.

FOR YOUR
FLOW CONTROL
....requirements

between 0.5 and 20 GPM
it's a WATERMAN
Full Range Adjustable
Regulator Model 1407-4



COMPACT
RELIABLE
RUGGED

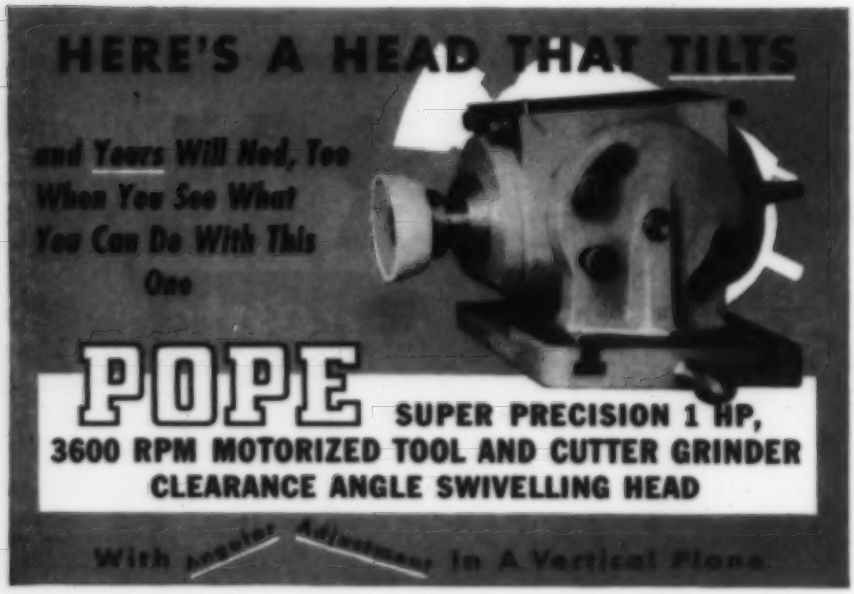
- Minimum to maximum flow adjustment obtained by 180° handle rotation.
- Flow rate changes easily accomplished under any conditions of pressure or back pressure.
- Adjustable handle tension eliminates need for wrenches and locking levers for changes in flow setting.
- Ideally suited for installations requiring frequent changes in operating speeds or throttling control during the machine cycle.
- Choice of control—either right or left rotation of control handle.
- Multiple control—with right and left hand rotation operator can control two operations simultaneously.
- Aluminum bodies housing steel working parts provide light weight units for easy handling and installation.

LOOK TO WATERMAN FOR THE ANSWER TO YOUR FLOW CONTROL REQUIREMENTS

Write for latest illustrated bulletin

WATERMAN
ENGINEERING COMPANY

725 CUSTER AVENUE • EVANSTON, ILLINOIS


HERE'S A HEAD THAT TILTS
and Yours Will Nod, Too
When You See What
You Can Do With This
One
POPE
SUPER PRECISION 1 HP,
3600 RPM MOTORIZED TOOL AND CUTTER GRINDER
CLEARANCE ANGLE SWIVELLING HEAD
With angular Adjustment In A Vertical Plane

Give this versatile head the nod and save time and money these seven ways:

1. You can use cup wheels for practically all clearance angles and thus produce a cutting edge on tools that lasts longer because it is stronger.

2. You can keep the tooth rest on the center line of the cutter for practically all grinding on centers or in the work head.

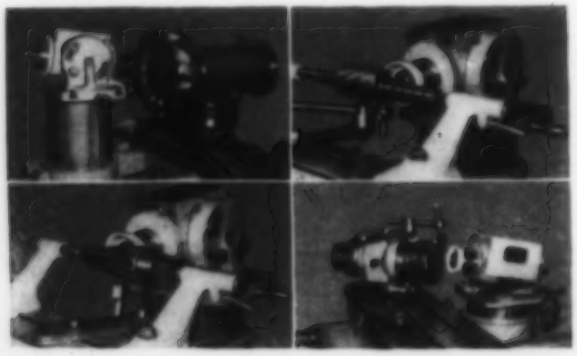
3. You can grind most cutters and reamers all over *with a single set-up* using the swivelling table and Pope tilting head.

4. You can read all clearance angles directly in degrees from the scale provided on the head. No more mistakes.

5. You can get the right clearance angle on such tough grinding jobs as slab mills, taper reamers, angular cutters and form tools.

6. You have one safe speed—3600 RPM—for all wheels generally used on cutter grinders. Heat checking of cutters is virtually eliminated.

7. You have a head that's so easy to adjust and use it saves you time and money every time you grind a tool.



No. 101

Ask us to submit complete specifications including price and delivery.

Specify POPE PRECISION SPINDLES

POPE MACHINERY CORPORATION

Stress Relief

LAST month J. P. Henderson, old habitue of engineering conventions, started his own guide book of practices and customs pertaining to them. With the idea of explaining to the young engineer how to get the most from such engineering meetings, he has now gotten him registered as a delegate, and urged that he become acquainted with the girls at the registration desk. And so, this month, he writes of

Girls and The Engineering Convention

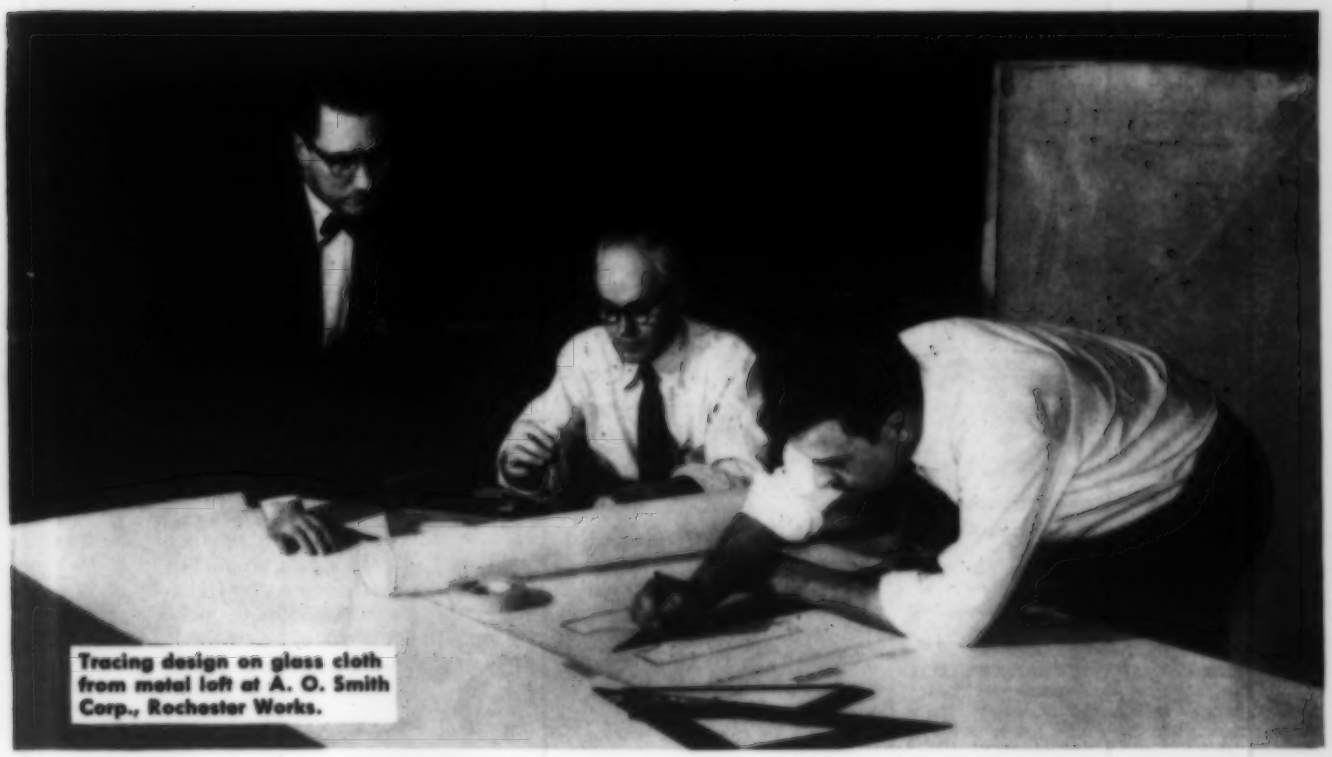
It's usually the duty of several of the permanent feminine staff of the engineering society headquarters to preside over the registration desk.

One of this group is sure to be the Secretary's secretary. Get acquainted with her. Get acquainted with the others, too, for by this means your visit to the convention can be really interesting.

Perhaps you and I are not thinking alike at this point. All of these "girls" run from 50 to 65 years of age, but they are all wise. They know almost everyone, they know everything that is going on or likely to go on. For their old friends they have free tickets for this or that. And they have a list of all of the industrial suite numbers in the hotel where, for the mere bother of glancing at Jones and Company's new Super-Inflamed Whatsit (which is on display) you can help yourself to a buffet at all hours, or sit in an easy chair and be served a free liquid refreshment.

Working the Angles

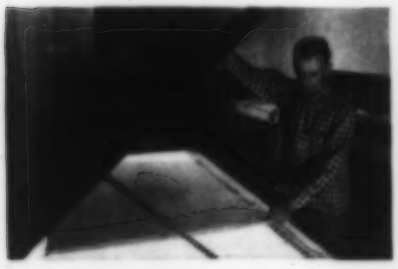
Do not overlook these possibilities. You know, of course, that at many such conventions, various manufacturing companies (in the hope of reducing their taxes) maintain such suites for entertaining "prospects." Unfortunately, one cannot merely walk in and



Tracing design on glass cloth from metal loft at A. O. Smith Corp., Rochester Works.

Valuable originals protected against wear and tear

At the A. O. Smith Corp.'s Rochester (N.Y.) Works, large drawings are made exactly to scale on glass cloth. Since these drawings often cost several hundred dollars each, A. O. Smith naturally does not wish to expose them to possible damage during print-making and to the wear and tear of excessive handling. Instead, they use intermediates made on Kodagraph Autopositive Paper.



Costing but a few cents a square foot, Autopositive produces positive photographic prints directly from the original drawings — without a negative step or darkroom handling. It can be exposed in standard print-making equipment and processed in standard photographic solutions. (A. O. Smith uses a vacuum-frame printer, which accommodates drawings up to 8 x 4 feet in size.)

No worries with Autopositive intermediates — they turn out sharp, legible shop prints time after time. Their dense photographic black lines do not smudge or smear. And they can be run at uniform, practical speeds in the company's direct-process machine.

In addition, A. O. Smith keeps an "Autopositive File" showing the history of changes in all their drawings. Before each revision, an Autopositive intermediate is made. Later on, direct-process prints showing the complete story of each design can be made from the intermediates as needed.

Kodagraph Autopositive Paper

"THE BIG NEW PLUS" in engineering drawing reproduction

Shows all the ways you can save with Kodagraph Autopositive Paper.

MAIL COUPON FOR FREE BOOKLET

EASTMAN KODAK COMPANY
Industrial Photographic Division, Rochester 4, N. Y.
Gentlemen: Please send me a copy of "Modern Drawing and Document Reproduction."

Name_____ Position_____

Company_____ Street_____

City_____ Zone____ State_____

Kodak

"LUBRIPLATE, THE OUNCE OF PREVENTION"

says
VULCAN IRON WORKS, INC.
of Chicago, Ill.

—a leading manufacturer of pile driving and extracting equipment

"For many years we have used LUBRIPLATE Lubricants for shop assembly, and have recommended them to our customers through your LUBRIPLATE Tag Plan. Our experience shows that if the proper lubricants are used from the beginning, there are fewer problems and parts replacements later. We consider LUBRIPLATE to be the best possible ounce of prevention."—
H. G. Warrington, Vice-Pres.

REGARDLESS OF THE SIZE AND TYPE OF YOUR MACHINERY, LUBRIPLATE GREASE AND FLUID TYPE LUBRICANTS WILL IMPROVE ITS OPERATION AND REDUCE MAINTENANCE COSTS.

LUBRIPLATE is available in grease and fluid densities for every purpose... LUBRIPLATE H.D.S. MOTOR OIL meets today's exacting requirements for gasoline and diesel engines.

For nearest LUBRIPLATE distributor see Classified Telephone Directory. Send for free "LUBRIPLATE DATA BOOK"... a valuable treatise on lubrication. Write LUBRIPLATE DIVISION, Fiske Brothers Refining Co., Newark 5, N. J. or Toledo 5, Ohio.

Stress Relief

demand a handout. After all it might have been a private party and that would prove embarrassing. By getting such numbers from the "girls" you are saved this pain.

Knowing them has other advantages. Are you looking for a

new job? Even if you are not, it may be comfortable to hear about openings, or to hear how much so-and-so has been offered. The girls know all about this too and can regale you with every brand of technical news. One can go on and on about the advantages of knowing these girls, just as they can go on and on with the news, but it's time now for the delegate to consider the General Assembly.

"Welcome"

Because of delayed arrivals, the convention usually opens officially the second day. The delegates in the largest auditorium are treated to an address of welcome by the governor of the state (if it's a small state), the mayor of the city, and the society president.

The experienced mayor can clearly be identified, for in welcoming you he refers to you as "scientists" and speaks of the contribution your "science" has made to society. This is the voice of experience speaking. Years before he inadvertently welcomed the electrical engineers at the chemists' meeting; some years after that he read the welcoming speech written by his office for the Metallurgical society and found that he could not pronounce "metallurgical." Then later he

(*Concluded on Page* 314)

SENIOR PROJECT ENGINEERS

Top leadership qualifications together with previous management level experience are necessary for these rare opportunities with American Machine & Foundry Company in our Greenwich, Connecticut location. These are growth opportunities with AMF, one of America's foremost companies in the field of automatic machinery and electronics. Ages 35 to 40.

M.S. in M.E.

10 years' experience in design and development of high speed automatic machinery; ordnance equipment; material handling equipment.

M.S. in E.E.

10 years' experience in design and development of radar equipment; electrical and electronic equipment.

JUNIOR PROJECT ENGINEERS

We also require a number of engineers with:

B.S. in M.E. or E.E.

Ages 25 to 30; 3 to 5 years' experience. This experience should be in the same fields as required for ME's and EE's above.

Security clearance will be required.

AMF

Please forward complete resume:
Mr. T. N. Hunsbedt

American Machine & Foundry
261 Madison Ave., New York, N. Y.

R & M SPECIALISTS INTEGRATE MOTOR AND MACHINE DESIGNS... TO ASSURE HIGHEST PERFORMANCE

Many factors must be considered in designing a new motor-operated product that will perform its intended functions accurately, economically, and with a low maintenance and failure rate. Much depends on the proper correlation and integration of motor and machine designs. A special knowledge of motor application can be valuable to you. Robbins & Myers motor design specialists can help you solve these problems, to whatever extent you desire.

The exact motor for your machine is worked out quickly and accurately, with systematic methods of designing motors. This might include, for example, the use of R & M's unique "Electrical Slide Rule." Electrical equivalents can be set up on the slide rule to simulate the conditions under which the motor must operate in your product. By this method we are able to investigate hundreds of different design possibilities, assuring the best motor for the job.

In some cases the answers point to a standard motor. And here, R & M offers a wide variety of types and sizes of complete motors or matched motor parts.

In other cases special motors are indicated. R & M is equipped to do a fast, thorough, economical job of custom-designing a motor that's exactly right for your product.

Don't settle for an "off-the-shelf" compromise. Standard or custom-designed, R & M will get you the right answer quickly —with no obligation!

R & M MOTORS AND MOTOR PARTS POWER MANY TYPES OF EQUIPMENT, SUCH AS . . .

Portable Saws	Routers	Nut Setters	Hedge Trimmers
Drills	Screw Drivers	Hammers	Lawn Mowers
Nibblers	Pumps	Polishers	Oil Burners
Lock Mortisers	Compressors	Planers	Surgical Instruments
Valve Grinders	Hones	Portable Grinders	Grease Guns
Vacuum Cleaners	Business Machines	Sirens	Vibrators
Fans	Cast Cutters	Advertising Devices	Die Sinkers
Sanders	Food Mixers	Ventilating Equipment	Waxers

R & M MAKES BOTH!
Fractional-horsepower motors and parts . . . from 1/200 h.p.

If it's an R & M, it's the Right Motor!

Integral-horsepower motors; famous R & M "All-Weather"* with sealed bearings. Up to 125 h.p.

**"All-Weather" is an R & M trademark*

This coupon will bring you prompt information. MD

Robbins & Myers, Inc., Motor Division, Springfield 99, Ohio

Please send me, without obligation, information on:

- ☐ Motor Parts for Portable Tools
- ☐ Universal Motors
- ☐ Capacitor Motors
- ☐ R & M "All-Weather" Motors —up to 125 h.p.
- ☐ Please have a Motor Specialist call

Product we manufacture: _____

Name _____

Title _____

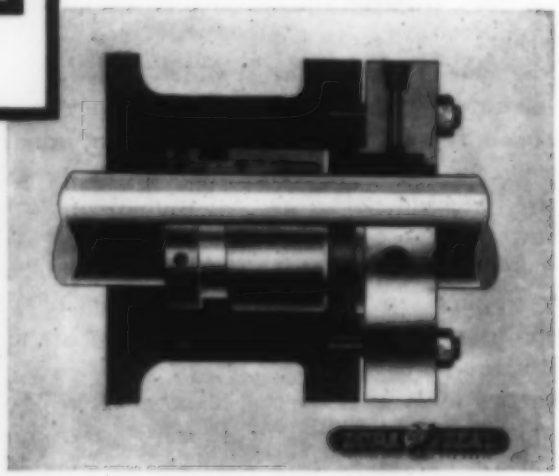
Company _____

Street _____

City & State _____

DURA SEAL

A Single Balanced Mechanical Seal for Light Hydrocarbons at High Pressures...



Now – perfect sealing for pumps handling light hydrocarbons up to 600 lb. pressures. Can be installed on your present equipment – no special sleeves or machining required.

FOR DETAILS – ASK FOR BULLETIN NO. 455-MD

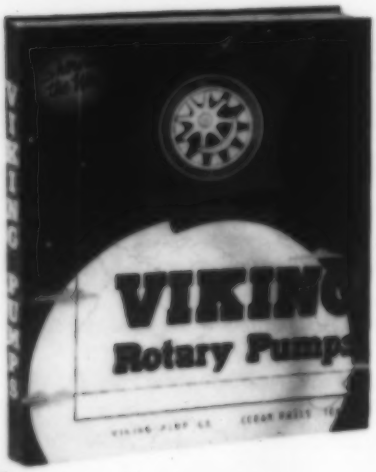
Send your sealing problems to us for free counsel

DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

Now Latest Information on Viking Pumps!

NEW CATALOGS

- ☐ B-H General Purpose Pumps
- ☐ C-H Heavy Duty Pumps
- ☐ D-H Underwriter Pumps
- ☐ E-H Jacketed Pumps
- ☐ F-H Sanitary Pumps
- ☐ G-H Oil Industry Pumps
- ☐ H-H LP-Gas Pumps
- ☐ I-H Hydraulic Pumps
- ☐ J-H Special Application Pumps



FREE Just check the catalogs you want. Attach to your letterhead, sign and mail.

VIKING PUMP COMPANY
Cedar Falls, Iowa
See our catalog in SWEETS

Stress Relief

(*Concluded from Page* 310)

found the universal solution, the identical speech that could be given month after month in welcoming most conventions. Instead of being definite, he uses the terms "science" and "scientist." He even found it appropriate for the Brewmasters convention.

The president of the society, in his annual address, has a difficult job on his hands. What can he say that is *significant?* What can he say that is *news?* As a comparative newcomer to conventions, the delegate should attend this session if for no other reason than to find out what prexy has dug up for this age-old problem.

The older, experienced delegate follows a standard procedure. Five minutes after the general meeting is scheduled to start, he looks through the door crack into the auditorium and notes the attendance. Are the seats full, or reasonably so? If so, he can return to the lobby and finish his newspaper. If not, a sense of duty

should impel him to rest on one of the seats inside. Mustn't let the organization down—a good attendance should be noted.

One sees whole rows of engineers following this plan, peek in and tip-toe away. I once knew an engineer who returned from a winter meeting with one bloodshot eye. He had "looked in" on all of the technical sessions, using this practice, and the meeting headquarters had been drafty.

We'll wind up our convention tour next month.

—J. P. HENDERSON

New freedom of design with U. S. PowerGrip "TIMING" BELTS

SMALLER PULLEYS • NO MORE OIL-RETAINING HOUSINGS
LONGER SERVICE LIFE • GREATER MACHINE EFFICIENCY

The designer shakes himself free of many obstacles when he can work with U. S. PowerGrip TIMING® Belts. These split-second power transmitters are used on hundreds of such machines as lathes, drill presses, electric typewriters, floor washing machines, saws. *The list grows day by day.* Check points below!

FAST DELIVERY
COMPLETE ENGINEERING SERVICE
FULL STOCKS

Absolutely no slippage or creep in the belt • No need for lubricants, oil-retaining housings—because there is no metal-to-metal contact • Very small pulleys can be used, thus permitting very short centers and high ratios. No take-up needed because belt is practically stretchless • H.P. range is 1/100 to 300 or more. *Stock* drives go up to 50 H.P., but wider belts and pulleys can be made to order in standard lengths and diameters • U. S. PowerGrip TIMING Belt permits lighter bearings, lighter metals—cuts costs • Immediate delivery from coast-to-coast offices.

Send for descriptive literature. Get in touch with any of the 27 United States Rubber Company District Sales Offices, or write to address below.

US RUBBER

"U. S." Research perfects it • "U. S." Production builds it • U. S. Industry depends on it.

UNITED STATES RUBBER COMPANY
MECHANICAL GOODS DIVISION · ROCKEFELLER CENTER, NEW YORK 20, N. Y.

Hose • Belting • Expansion Joints • Rubber-to-metal Products • Oil Field Specialties • Plastic Pipe and Fittings • Grinding Wheels • Packings • Tapes Molded and Extruded Rubber and Plastic Products • Protective Linings and Coatings • Conductive Rubber • Adhesives • Roll Coverings • Mats and Matting

UNITED
CLUTCH HEAD
SCREWS

If you are interested in reducing operator fatigue, screw driver costs, damage to assemblies by screw drivers skidding, and increasing your efficiency in plant and field applications, it will be to your advantage to study the usage of Clutch Head® screws in your production problems.

While the Type A bit was designed to give you the greatest ease in repair work, a common screw driver, of the proper width to engage the clutch recess, will easily unscrew or seat the screw.

Write for engineering booklet.

® Reg. U. S. Pat. Off.

UNITED SCREW and BOLT CORP.
CHICAGO 8, ILL. • CLEVELAND 2, OHIO
NEW YORK 7, N. Y.

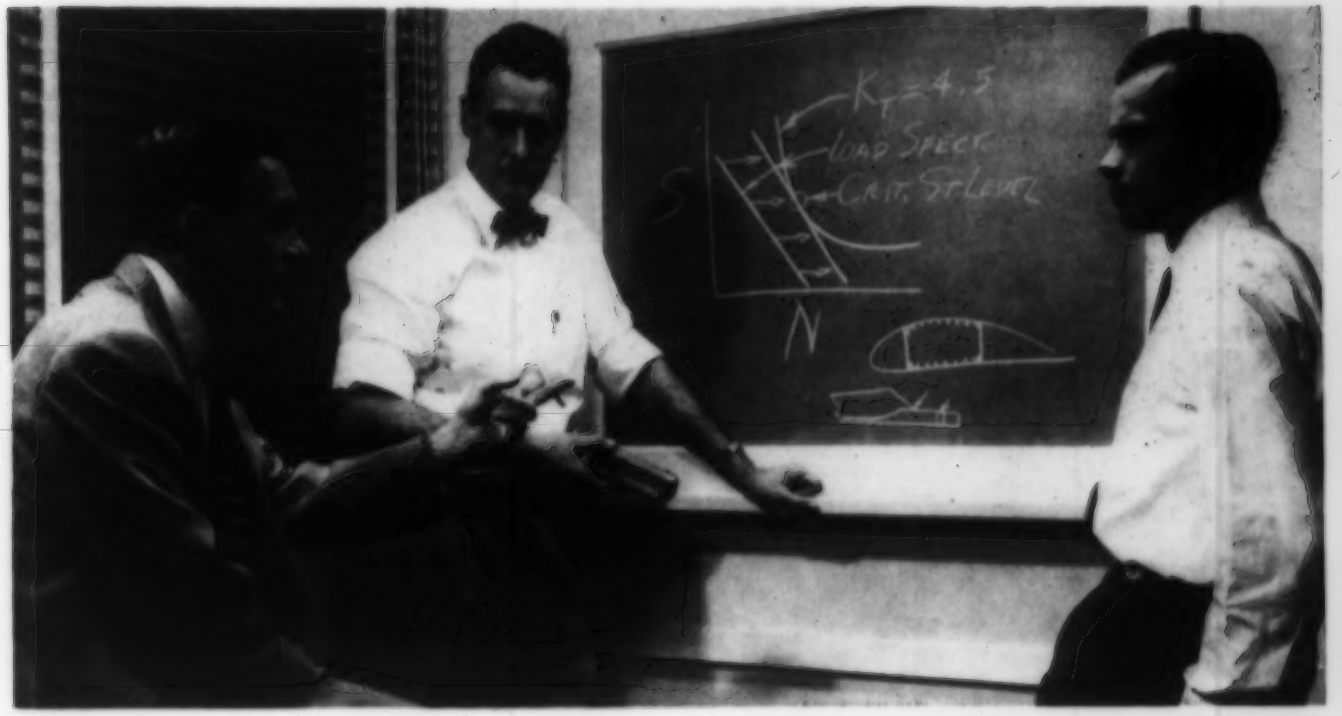
NOTEWORTHY

Patents

TWO-WAY SPRING MOTOR capable of exerting controlled force in either direction consists of a spiral spring fastened at its midpoint to a stationary member. Proper spacing of a movable driven member with relation to the stationary piece keeps the spring from coiling. If the ends of the spring are allowed to coil up, the coils move toward the midpoint. This principle is utilized in this invention to provide the motive power to the driven piece. Receptacles are cut into the driven element to receive the coils. In operation, the driven element is manually moved to start one end of the spring into its receptacle. As it feeds into the space, it coils up and exerts force to move the driven member toward the midpoint of the spring. A like arrangement at the other end of the spring enables the mechanism to slide or rotate the driven piece in the opposite direction. At the midpoint, no force is exerted in either direction. Sliding door openers and closers and switches are among the applications recommended for the mechanism. *Patent 2,670,198 assigned to Eastern Metals Research Co. Inc. by L. B. Glaser and F. A. Votta.*

PLASTIC SPRING for use in limited space under heavy loads consists of a hollow cylinder filled with a compressible material. Load is applied to a movable piston fitted into one end of the cylinder, the other end of the cylinder being closed. Under load the plastic material, preferably a hard silicone, is compressed. When the load is relieved, the piston returns to its original position. Since the load is distributed equally over the compressible solid, a smaller size spring for a given load-carrying capacity can be used. The springs may also be nested with the cylinder of one engaging the piston of the one below. *Patent 2,668,049 assigned to Wales-Strippit Corp. by P. H. Taylor.*

RADIAL PISTON PUMP having ball check valves integral with each piston is operated by rotation of an eccentric ring. An internal coil spring in each piston keeps the ball valve closed except when the piston is at its innermost position. Here the ball valve is free to open and the piston fills with fluid. As the eccentric rotates, the piston is driven outward, the coil spring holds the ball valve closed, and the fluid



J. F. McBrearty, chief structures engineer (left), discusses fatigue test program of integrally-stiffened wing lower surface structure of Super Constellation Model with E. H. Spaulding, structures division engineer and J. G. Leewolt, stress engineer. Lockheed's 500,000 lb. Force Fatigue Machine was used in test program.

Advanced structures facilities speed careers of Lockheed Engineers

Ralph Oliva, research engineer, examines Super Constellation skin for signs of fatigue failure.

Engineers in Lockheed's Structures Division are supported by unmatched research and testing facilities in their constant effort to increase strength while decreasing weight.

Among those facilities are the Lockheed-designed 500,000 Lb. Force Fatigue Machine, first of its size; Shimmy Tower, only one in private industry; and Drop Test Tower, largest in the nation.

Facilities such as these give engineers a major advantage in making technical advances – and thus advancing their careers. Moreover, the large number of projects always in motion at Lockheed mean continuing opportunity for promotion as well as job security.

Why Lockheed needs Engineers with Structures training:

1. **"Fail-Safe" Structures** – Lockheed has begun an extensive pioneering effort in the new concept of "fail-safe" structures. Studies are being applied to virtually all phases of Lockheed's diversified development program – already the largest in the company's history.

2. **New studies in:** Effect of high temperatures on structures; optimization of thin-wing designs and other aero-elastic problems; new materials such as ultra-high heat treat steel; panel instability at extremely high speeds.

Engineers interested in the "Fail-Safe" program and other studies are invited to write E. W. Des Lauriers, Dept. MD-3

Lockheed
AIRCRAFT CORPORATION
BURBANK, **California**

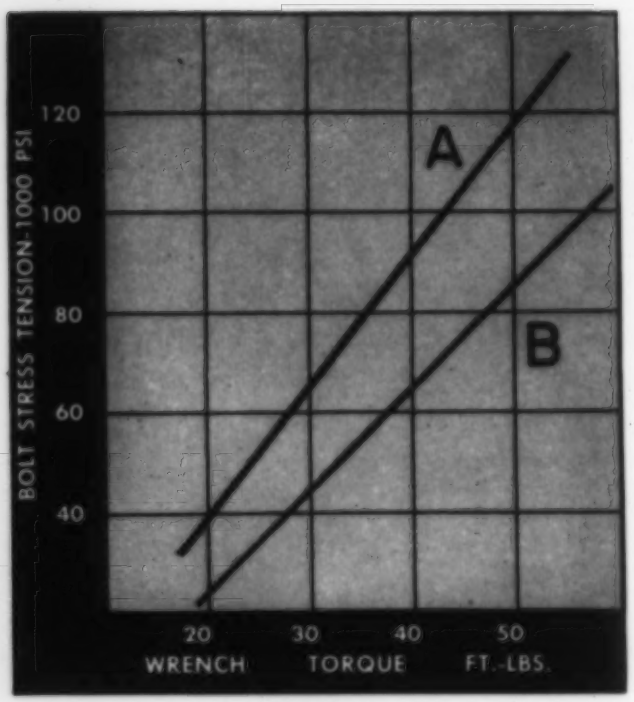


Figure 5

24 page engineering data... Section

Figure 5, along with a Guide Chart, for calculating wrench torques for Standard, 12-Pointer, Marsden and Huglock nuts, are to be found on page 8 and 9 in a new twenty-four page Engineering Data section of our catalog. Besides this specific information, considerable space is devoted to all of the variables that must be considered, to properly handle this important production operation. The subject of Bolt Tightness and Wrench Torques is just one of fourteen topics, concerning the technique in the manufacture and the proper installation of our product, that is covered in this brochure — Requests for this literature will be handled promptly.

NATIONAL MACHINE PRODUCTS COMPANY

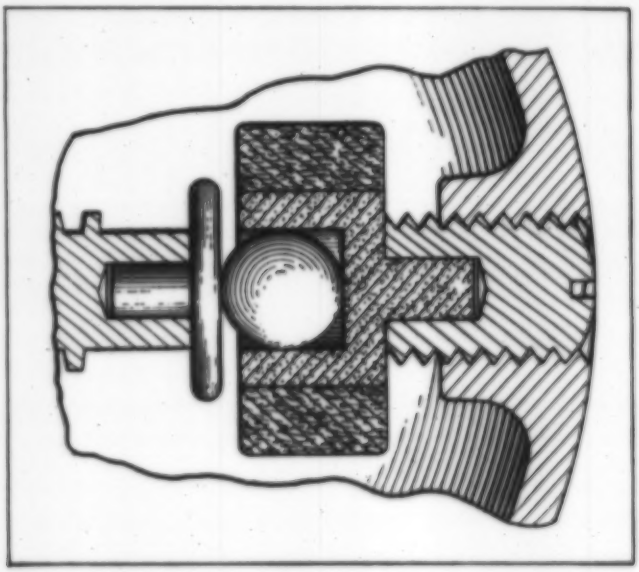
Manufacturer of Standard and Special 12 Pointer and Hexagon Nuts..."Huglock" and "Marsden" locknuts.

44225 Utica Rd., UTICA, Michigan

Noteworthy Patents

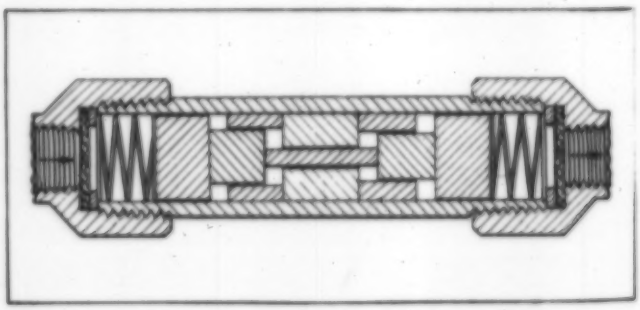
is pumped out through ports in the top of each cylinder. Friction is reduced by use of a needle bearing between the eccentric and the piston actuating ring. Special jets provided in each piston permit automatic lubrication of the moving parts while the pump is in operation. *Patent* 2,683,423 *assigned to Simplex Engineering Co. by T. E. Raymond.*

BALL THRUST BEARING seating in a metal powder cup absorbs shaft end loads with minimum bearing wear. Lubrication is provided by a wick encircling the cup so that the porous material always con-



tains an adequate supply of lubricant. A modification of the invention provides a porous ball in a metal cup; space between the ball and the cup is filled with a lubricant. *Patent* 2,684,881 *assigned to Birtman Electric Co. by C. H. Sparklin.*

SHOCK ABSORBER for fluid pressure lines consists of a series of interconnected movable pistons of different diameters mounted inside calibrated cylinders.



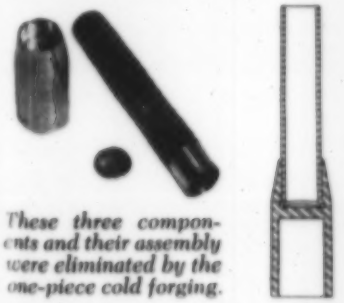
ENGINEERING OPPORTUNITIES—
Mechanical, Design, Sr. Draftsmen.
Forward complete resumé to
Personnel Division.

HUNTER DOUGLAS ONE-PIECE COLD FORGINGS

replace 3 piece unit, eliminate assembly, solve gas leakage problems!

A typical example of how Hunter Douglas cold forgings simplify everyday design problems

A most critical requirement in the production of an ordnance component was a perfect seal against the escape of high pressure gases. Fabrication by conventional procedures involved the assembly of three separate pieces—a screw machine part turned from bar stock and bored from each end; a separate sleeve machined from tubing, and a stamped Welsh plug. The three parts were unitized by expanding the Welsh plug within the sleeve, forcing walls into a machined groove within the head.



These three components and their assembly were eliminated by the one-piece cold forging.

To simplify the design, insure leak-proof construction and eliminate costly machining and assembly time, Hunter Douglas engineers suggested a cold forging from HD-11-T6, a high strength aluminum alloy.

All internal and external diameters of the cold forged component are now formed in a single, instantaneous press operation. No joints exist to cause leakage, consequently rejects are negligible. The cold forging, being highly stressed, easily withstands bursting pressures of 5500 psi without distortion. With its remarkable simplification in design, the cold forging requires fewer machining operations, thus saving both time and unnecessary metal waste.

Hunter Douglas Cold Forgings can be mass-produced in any required numbers and to cover a tremendous range of design requirements. If your components require *walls of zero draft, high physical properties, employ tubular shapes with or without a closed end, and must meet close dimensional tolerances,* HUNTER DOUGLAS COLD FORGINGS may provide the answer. Our engineers will give you a prompt analysis upon submission of a blueprint or sample part.

Hunter Douglas Cold Forgings cover a multitude of needs. Note wide variation in part geometry. Many complex designs formerly considered impossible to produce by cold forging now respond to new techniques developed at Hunter Douglas.

DESIGNERS:

If you want to know more about Hunter Douglas Cold Forgings write on your company letterhead for this free 40 page book, now on the press!

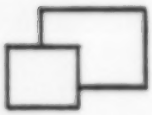
Hunter Douglas Corporation

HUNTER DOUGLAS CORPORATION • DEPT. MD-3 RIVERSIDE, CALIFORNIA TELEPHONE OVerland 3-3030

FASTENS ANYTHING ANYWHERE

TAKE ONE ROUND HOLE

ANY SIZE IN THIN OR SOFT

MATERIALS  ANY TYPE.

PUSH IN THE NEW, THREADED INSERT OR

TAPPED-HOLE OF BANC-LOK

DESIGN WITH BOLT TO FIT.

LOCKS AUTOMATICALLY.

And there you have the ideal, low-cost method (Banc-Lok, of course) of blind fastening to sheet metals, plastics, or wood.

Banc-Lok is a new, exclusive development by Boots . . . leading manufacturers of self-locking nuts for aircraft.

BANC-LOK

by **BOOTS**

BOOTS Aircraft NUT corporation

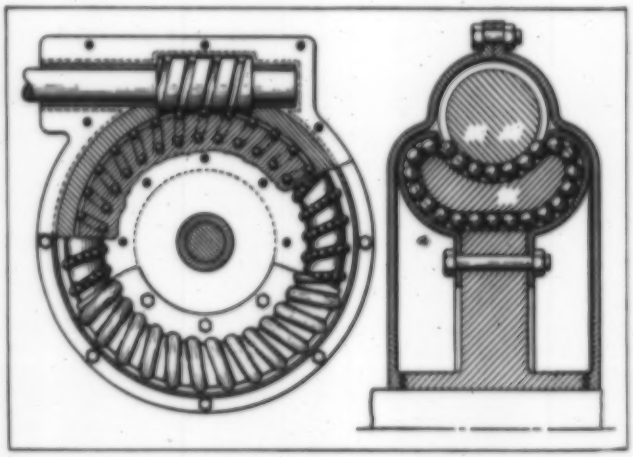
BANC-LOK DIVISION

536 NEWTOWN TURNPIKE • NORWALK, CONNECTICUT

Noteworthy Patents

Cavities of varied volumes are formed within the cylinders at the ends of each piston. Damping action is based upon the calibration of the bores to permit leakage of the fluid around the pistons. Pumping action of the pistons, when acted upon by the fluid pressure, produces varied rates of flow between cavities. Degree of damping is determined by the rate of flow through the calibrated bores. Light springs at each end of the piston assembly return the pistons to the center position. Damping in one direction only may be accomplished with a modification described in this patent. *Patent* 2,674,096 *assigned to Tricon Inc. by F. W. Marshall.*

BALL BEARING WORM DRIVE reduces friction in two ways—driving through bearing balls placed between the worm and worm wheel, and supporting the worm wheel in its housing on the same bearing balls. A helical groove around the worm wheel in combination with a mating helical-grooved housing forms a raceway for the balls and the support for the wheel.

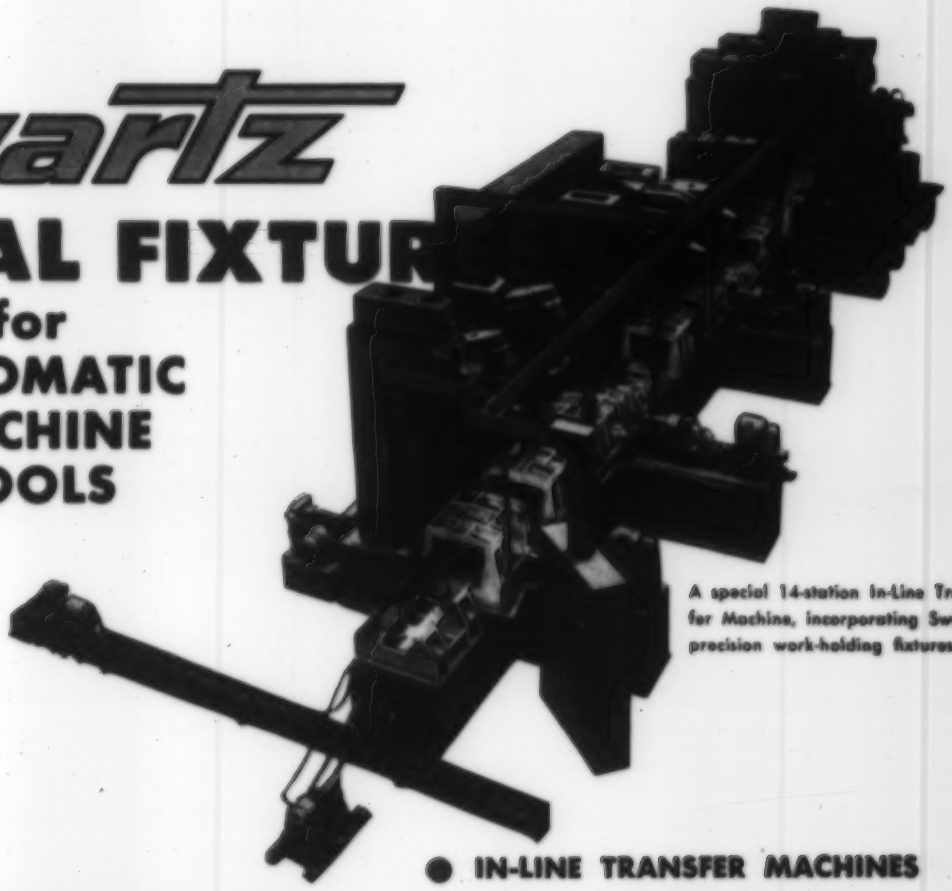


Cutting away a portion of the raceway allows the grooved worm to engage the balls. Thus, torque is transmitted from the worm through the bearing balls. The invention is especially adapted to applications requiring low friction and where the gear need not be rotated more than about 150 degrees. *Patent* 2,673,473 *assigned to Oliver Corp. by A. W. Phelps.*

AUTOMATIC TORQUE LIMITING of rotating shafts is accomplished with a clutch having rubber disk clutch faces. Cup-shaped recesses in the rubber hold steel balls around the circumference of the disks. Torque is transmitted by interlocking the balls. Upon overload, the balls are forced deeper into these resilient faces, causing them to disengage and the clutch

Swartz

SPECIAL FIXTURES for AUTOMATIC MACHINE TOOLS



A special 14-station In-Line Transfer Machine, incorporating Swartz precision work-holding fixtures.

- **IN-LINE TRANSFER MACHINES**
- **ROTARY INDEX MACHINES**
- **TRUNNION INDEX MACHINES**
- **SINGLE-STATION MULTIPLE-OPERATION MACHINES**

Station No. 1—Special 14-station In-Line Transfer Machine. Swartz fixtures were specified for dependable on-the-job fixture performance.

Here is a 4-station Rotary Index Machine, equipped with Swartz fixtures. Swartz fixtures were specified for maximum service and dependability.

There are many advantages in specifying Swartz precision work-holding fixtures . . . advantages which are shared alike by both buyer and builder of automatic machine tools.

Of particular importance, is the seasoned experience, and specialized know-how which Swartz has gained through more than 30 years of fixture-building service to the machine tool industry. This experience and skill, together with the modern facilities needed to do the job, make Swartz service *complete* . . . from part print to finished fixture!

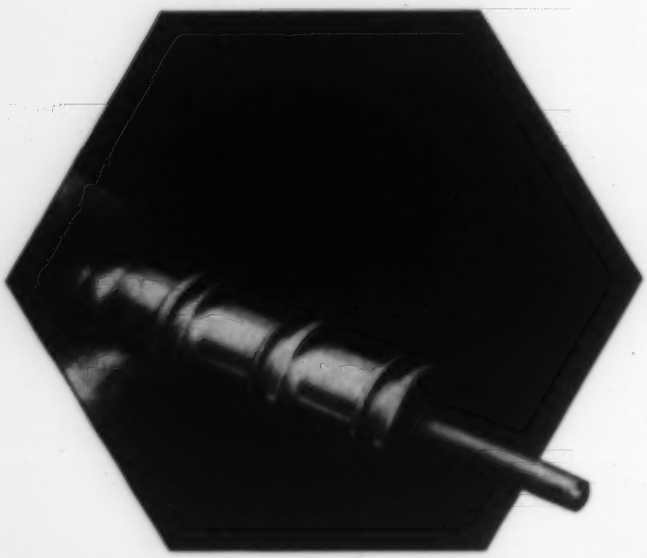
There are other advantages, too, in specifying and using Swartz fixtures. It will pay you to get the facts! A Swartz engineer will be glad to discuss your fixture requirements, and point out the many ways Swartz service can work for you *profitably*.

Write Today **Swartz service is outlined in this interesting new brochure, "Advancing Automation." A copy will be mailed on request.**

SWARTZ TOOL PRODUCTS
Division of Jefferson Corporation
13338 FOLEY STREET • DETROIT 27, MICHIGAN

Designers and Builders of: Pump Jigs • Standard Fixtures • Fixture Locks • Special Fixtures for Automatic Machine Tools.

There is a right way to deep drill this aluminum part



Alcoa offers the answers here . . .

On many screw machine jobs there are operations which can be done in different ways, but, there is usually just one "best" way. To supplement your own experience, Alcoa® offers users of Alcoa Aluminum Screw Machine Stock a complete technical packet containing: calculators for feeds, speeds and properties; an engineering handbook on machining aluminum; a booklet of corrected tool diameter tables; case histories of savings; a conversion chart for alloy designations. The complete packet is free for the asking. Just fill out and mail this coupon today.

ALUMINUM COMPANY OF AMERICA
873-C Alcoa Building, Pittsburgh 19, Pa.

Gentlemen:
Please send your technical packet on aluminum screw machine stock to:

Name _____ Title _____

Company _____

Address _____

ALCOA ALUMINUM

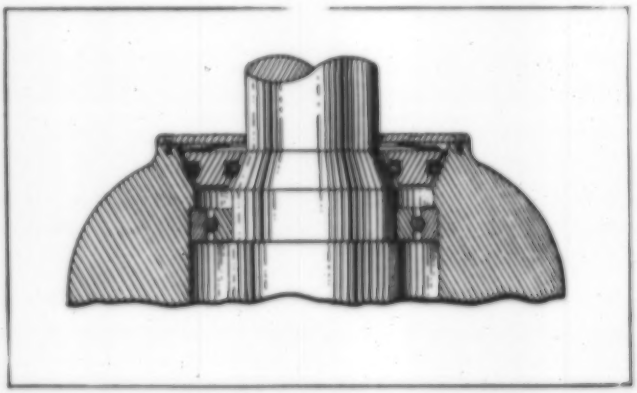
ALUMINUM COMPANY OF AMERICA

Noteworthy Patents

to slip. When the overloaded condition is removed, pressure on the balls is relieved and they spring back to their normal position. Overload point of the clutch is determined by the resilience of the rubber facing. *Patent* 2,683,362 *assigned to Le Roi Co. by S. Bowman.*

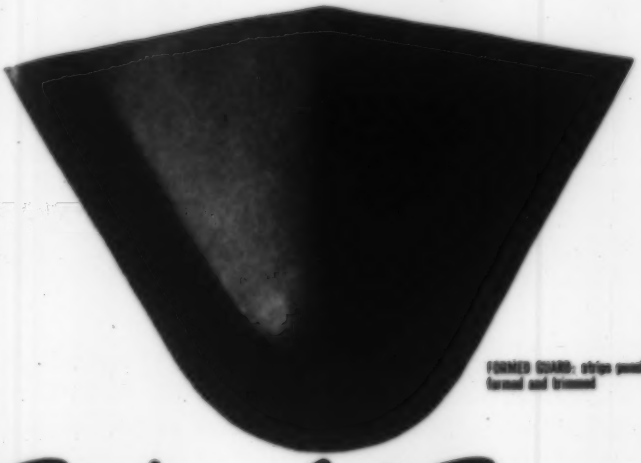
AUTOMATIC FLOW CONTROL of high-pressure fluid lines is accomplished with a lightweight valve designed to respond to small differential pressures. A novel arrangement closes off the valve spring chamber without friction sealing when the valve is open and protects the spring from possible damage from the high-pressure fluid. As a result, sensitivity of the valve is improved because a lighter spring can be used. Chattering is minimized by designing the valve to open fully at low pressure differentials and by cushioning action of a nylon valve seat. *Patent* 2,675,021 *assigned to Weatherhead Co. by F. R. Allin.*

LEAKTIGHT SEALING of a rotating shaft is accomplished by a seal assembly consisting of inner and outer O-rings mounted on a metal ring of trapezoidal cross-section. Sealing action is provided by the O-rings which are held in grooves in the tapered surfaces of the metal ring and form a seal



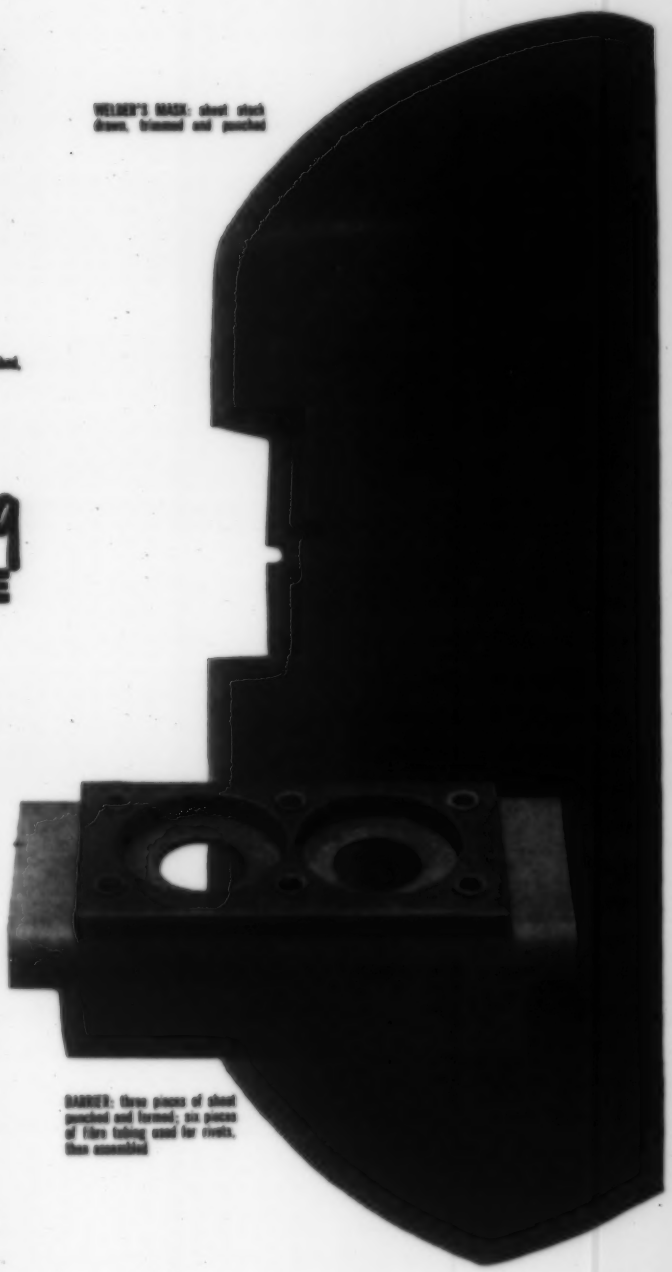
between the inside of the ring and a tapered portion of the shaft, and between the outside of the ring and the housings. Minimum sealing pressure is maintained by a retaining spring which also takes up variations in sealing pressure due to end play of the shaft. *Patent* 2,678,837 *assigned to Raytheon Mfg. Co. by R. A. Griefen.*

Copies of the patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.



FORMED GUARD: strips punched, formed and trimmed

For Low-Cost Forming
C-D-F DIAMOND FIBRE



WELDER'S MASK: sheet stock drawn, trimmed and punched

- Arc resistant
- Non-corroding
- Mechanically strong
- Good dielectric qualities
- Easily formed and machined
- Light weight

For many product applications, Diamond Vulcanized Fibre is a proven, logical answer. Here is a low-cost material that can be bent, formed and drawn into permanent shapes. The "fibres" flow when moisture, heat and pressure are applied. They "set" as heat and pressure remove the moisture. Repeated moistening and drying never alter the nature, structure or quality of vulcanized fibre.

Deep shapes, such as welders' helmets, are made from a special "long fibre" C-D-F grade, a medium density, lightly calendered fibre with high impact strength.

C-D-F first made fibre in 1895 and has a wealth of manufacturing and fabricating experience. At Bridgeport, Pa., C-D-F has its own rag paper mill, is perhaps the world's biggest rag picker. Good vulcanized fibre depends on good, clean rags. C-D-F uses every human and mechanical means to keep Diamond Fibre free of metal. Thin and thick fibre in every size, type and color is stocked. Fibre materials handling equipment is manufactured for every industry.

Also, C-D-F does big-scale fabrication and forming at its Newark, Del., plant: Railroad track insulation, welders' helmets, machine covers, athletic equipment are formed here. Tubes, rods and combination fibre and laminated plastic Dilecto conite fuse tubing are major C-D-F Newark products.

BARRIER: three pieces of sheet punched and formed; six pieces of fibre tubing used for rivets. Then assembled

GEAR: sheet sawed, turned, milled, drilled

TRACK INSULATION: sheet stock sheared, formed and punched

C-D-F IS A BIG, RELIABLE SOURCE OF SUPPLY!

Good deliveries, good prices, reliable products. That is the reputation of C-D-F with the world's leading users of vulcanized fibre. Whether your needs are big or small, C-D-F is a worthy manufacturing facility . . . ready to work for and with you. Call your C-D-F sales engineer (offices in principal cities). Write for Diamond Vulcanized Fibre catalog and samples.

Continental-Diamond Fibre

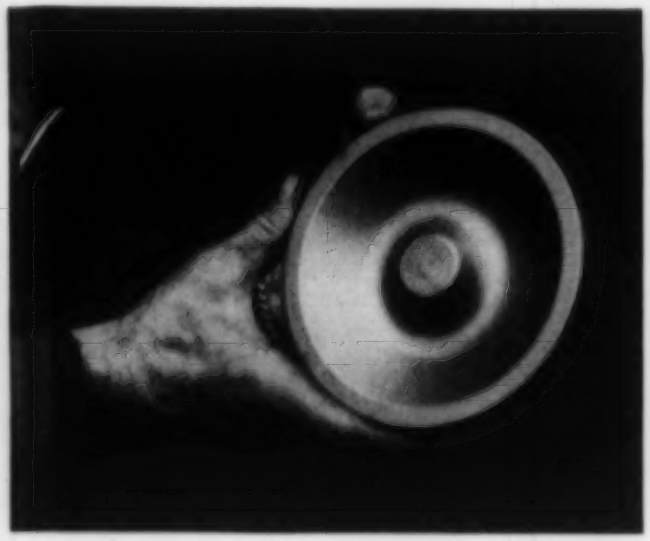
CONTINENTAL-DIAMOND FIBRE COMPANY

NEWARK 23, DELAWARE

Will you be standing in your

COMPETITION'S SALES SHADOW?

ELECTRUNITE® STAINLESS STEEL TUBING CUTS COSTS ON UNDERWOOD CALCULATING MACHINES. The cylinder in the carriage shock absorber must have a smooth inside finish to reduce drag, accurate bore, little diameter variation, negligible eccentricity. Underwood reports good service life plus a saving of 75 cents on material costs for each shock absorber.



SAVE WEIGHT WITH REPUBLIC TITANIUM. This wonder metal weighs only 56 per cent as much as steel, but it's just as strong. Often stronger. There's a big market for Titanium forgings like the compressor rotor shown above. And they can be produced to accurate dimensions and in a range of physical properties that is usable and reproducible. Republic Titanium can also be milled, threaded, turned, tapped, drilled and honed.

REPUBLIC IRON POWDER OFFERS NEW PROFIT OPPORTUNITIES for mass producing certain parts faster, more uniformly and at less cost. Or fabricating complicated shapes which are difficult to produce economically by other means. Republic metallurgists can help you determine iron powder's suitability to your parts. Or, they will suggest alternate methods or materials better suited to your operation.

The sales figures may not show it now. But a month, six months, a year—and they might not look so good. Then, what will you do?

We suggest one thing: look into Republic Enduro® Stainless Steel.

We know that making a product out of Enduro Stainless Steel can often put a silver lining in a sales picture. And we at Republic will be glad to help you.

We've been making stainless steels for more than thirty years. We pioneered many of their uses. We developed many alloys ourselves. And we know how to put them where they will do the most good.

Why not talk things over *before* your competition casts a shadow? Then we can keep your product out in the sunlight. Right where customers can buy it.

And will want to buy it.

Call your nearest Republic District Sales Office. Or send in the coupon for more information.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL

REPUBLIC STEEL CORPORATION
3130 East 45th Street, Cleveland 27, Ohio

Please send more information on:

- ☐ Republic Titanium
- ☐ Enduro Stainless Steels
- ☐ Republic Iron Powder
- ☐ ELECTRUNITE® Stainless Steel Tubing & Pipe

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

K-7000A

FOR EXAMPLE

This special screw was formerly made in two parts and spot-welded together. Elco now produces this part, in one piece, by the Cold Heading method at a savings of $13.26 per thousand.

OVER 30 YEARS EXPERIENCE MAKING SPECIALS AND STANDARDS

ELCO TOOL AND SCREW CORPORATION

1950 BROADWAY • ROCKFORD, ILLINOIS

New Machines

Materials Handling

Low-Profile Truck: Electrically powered rider type fork truck for low headroom operations is highly maneuverable. Its low center of gravity results in good load control and stability. Seat of the truck is just 32 in. above the ground, and operator's head is less than 68 in. above the ground, which is the height of the fork masts. Single lift is 53 in.; telescopic lift, 102 in. Masts can be tilted 10 deg backward and 3 deg forward. The truck is available in capacities ranging from 1000 to 4000 lb, monolift or duolift. *Automatic Transportation Co., Chicago, Ill.*

Die Handling Trucks: Ranging in capacity from 10,000 to 100,000 lb, new hydraulically operated trucks perform numerous die handling operations. Two hydraulic cylinders located along the sides of the truck's platform transmit power independently to pusher bars by means of a pair of roller chains recessed in the surface of the platform. Independent operation of pusher bars permits turning the die as it is pushed off the truck. Hydraulic power provides slow and precise positioning of dies on press beds. Low level of the truck platform when in its base position facilitates servicing of bed presses. Typical die setting time with a 14,000-lb die is 8 minutes; removal can be accomplished in less than 5 minutes. *Elwell-Parker Electric Co., Cleveland, O.*

Electric Fork Truck: Stand-Up type Load-Mobile fork truck is operated by a foot switch having two speeds forward and two speeds reverse. Automatic braking is provided when the unit is unattended. A switch mounted near the steering wheel controls forward and reverse movement. Truck is powered by two storage batteries which are located on either side of the operator. The batteries, either 12-v units connected in parallel for independent or simultaneous use, or 6-v units connected in series, provide up to 800 amp-hr capacity. Truck measures 31 or 42 in. wide and 58¾ in. long, not including forks. Turning radius is 52 in. *Market Forge Co., Everett, Mass.*

Metalworking

Combination Arc Welder: Idealarc welder provides a type of welding arc for every type of manual welding application, permitting selection of either ac or dc and either a soft or forceful arc. Welder is available in several combinations. It can be obtained as an ac welder without the dc; a dc package can be attached in about an hour when needed. It is also available as a combination ac and dc machine with selection of either current made by means of a switch. Different output capacities of dc and ac can be combined to fit the machine to the job requirements. Both

Tomorrow's ideas are taking shape today

with BRIDGEPORT Aluminum Extrusions

Designing with the future in mind? Look to extruded aluminum shapes to cut costs and improve your products. And look to Bridgeport for the very latest in ideas and manufacturing techniques.

We can extrude standard or specially engineered shapes in all extrusion alloys—with properties to meet your specifications. Our research and development teams are ready *now* to help you design for tomorrow's competition.

Look ahead with Bridgeport for the best in aluminum extrusions... and the latest in forgings, too. Prompt service is as near as your phone.

For the very latest in

BRIDGEPORT ALUMINUM

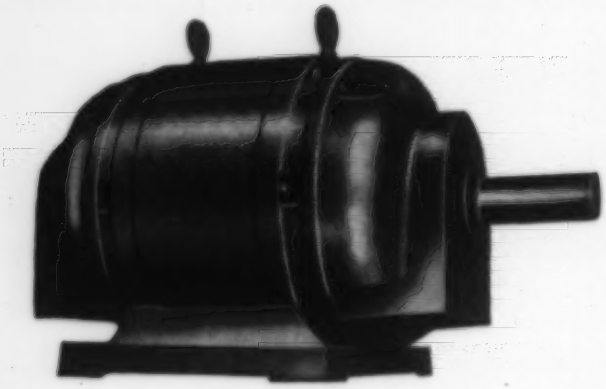
BRIDGEPORT BRASS COMPANY, ALUMINUM DIVISION, BRIDGEPORT 2, CONNECTICUT

Offices in Principal Cities

EXTRUSIONS FORGINGS

VALLEY
BALL BEARING MOTORS

STAY ON THE JOB... LONGER



When specifying the power unit for your machinery, bear these exclusive VALLEY features in mind!

- Specifically designed for 'round-the-clock' duty in high temperatures.
- Drip proof and splash proof, semi-enclosed construction protects motor from harmful liquids and flying particles.
- Fully enclosed ball bearings reduce friction 75% to provide a saving in power.
- Built in ½ to 75 horse power sizes for wide adaptability in your power planning.

VALLEY Motors, stay on the job longer, even under heavy and continuous power demands. Thus for economical power that will last the life of your equipment — always specify VALLEY.

TOTALLY ENCLOSED FAN COOLED

The latest development in Air-Cooled, Ball Bearing motors. Totally enclosed to assure protection against dripping or splashing liquids, metal chips, and damaging dust. 2 to 60 h. p.

Write For Descriptive Literature.

VALLEY ELECTRIC CORPORATION
4221 FOREST PARK BLVD. - ST. LOUIS 8, MO.

voltage and amperage are controlled to provide desired arc characteristics. Dual-control provides continuous current control through a rotating core in a separate control circuit and also has a switch to permit control of the open circuit voltage. Models are available for 300, 400 and 500-amp ac, combined with dc capacities in 200, 300, 375 and 450-amp. *Lincoln Electric Co., Cleveland, O.*

Belt Grinder: BG-8 Automat abrasive belt grinder flat-grinds and polishes small metal parts rapidly and accurately. It is equipped with a self-powered, continuous work feed and an 8 x 107-in. abrasive belt. Manually loaded workpieces are ejected automatically. Feed unit has twenty-one 3¾ x 6¼-in. fixture plates. Size of parts governs number which can be loaded on each fixture plate. Moved by parallel roller chains, each fixture plate is tracked to the leading edge of the abrasive belt, riding on hardened and ground shoes over hardened and ground steel rails. As work advances to belt surface, it is fed slowly across the belt, then retracted quickly before reaching the far edge of the belt. Feed speeds are variable; fixture plate travel can be set at 1090, 1350 or 1750 operations per hour. Machine is 48 x 48 x 72 in. high. *Engelberg Huller Co. Inc., Syracuse, N. Y.*

Single-Point Presses: Twin-geared Steelweld single-point presses are straight-side, tie-rod type. Mechanically powered and of welded steel construction, machines have low-inertia, air-operated clutch and brake unit; barrel type adjustment; nonmetallic, non-scoring guides; and automatic lubrication. Air cushions are designed with the cylinder opening downward to prevent entrance of foreign materials. Sizes of machines range from 150 to 500 tons, and bolster areas are 30 x 36 in. to 42 x 48 in. Operating speeds are from 10 to 20 strokes per minute. Presses with other specifications can be engineered to suit specific requirements. *Cleveland Crane & Engineering Co., Wickliffe, O.*

Spring Grinder: Bench-mounted, double-end disk grinder simultaneously grinds both ends of compression springs. It is used for both small and large production runs. Machine accommodates springs with 0.010 to 0.0625-in. wire diameters, ⅛ to 1½ in. in OD and ⅛ to 4½ in. in length. Squareness of grinding is usually within 2 deg. An adjustable stop can be set to control the travel of the wheels, thereby holding spring lengths to accuracy of a few thousandths of an inch. Grinding speed varies with size and quantity of springs. One hundred springs ⅜-in. OD, 1 in. long, made from 1/32-in. music wire, can be ground in 2 or 3 minutes. Machine has two 1-hp, 1800-rpm motors with special thrust bearings and individual starters. Grinding wheels are two standard 10-in. diameter, 1-in. thick steel-back, nut-inserted, aluminum oxide abrasive disks. Machine measures 13½ x 17 x 38 in.; weighs 300 lb. *Carlson Co., New York, N. Y.*

Belt and Disk Sander: Combination sander includes a balanced, heavy-duty 10-in. disk and a 6-in. belt sander on a 24-in. surface. The latter can be operated horizontally or vertically on a work bench or floor

Reliance

SNAP RINGS

Save Man Hours

Money and Material

Now it's easy to position gears and bearings on shafts without resorting to countless hours of intricate and expensive machining operations. Nor do you sacrifice quality when you let Reliance Snap Rings do the same job on shaft assemblies, bearing applications and counterbores that formerly required many man hours and wasted materials.

Reliance Snap Rings form a solid shoulder able to withstand predetermined thrust loads simply by machining a groove into a shaft and snapping in a Reliance Ring. Compare this to the waste in time and materials of machining the entire length of the shaft to form a shoulder. Wherever it is practical from a design standpoint, Reliance engineers can show you how to save man hours, money and material by switching from expensive machining operations to Reliance Snap Rings. You will find more detailed information in our Engineering Folder 4K/3 which we will be happy to send at your request with no obligation.

RELIANCE DIVISION, MASSILLON, OHIO

EATON MANUFACTURING COMPANY

Springotes & Seals · Snap & Retaining Rings · Special Steels · Spring Lock Washers · Hex-Pan-Nut

Detroit • Chicago • St. Louis • San Francisco • Montreal

ARE REGISTERED TRADEMARKS OF THE EATON MANUFACTURING COMPANY

Save up to 40% With Replaceable

Self-Aligning "MONOBALL" Bearings

At overhaul time, don't throw away entire rod end bearings. *Save the rod end housings* and replace only the bearings. You can do this with MONOBALL® Spherical Self-aligning Bearings and save as much as 40%. No special tools required . . . use any arbor to take out bearing, then re-stake new bearing.

For long service life and assurance of getting the right bearing for your service requirements, insist on MONOBALL® Spherical Self-Aligning Bearings.

CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Moly Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Moly Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Plain types in bore sizes 3/16" to 6". Rod end types in sizes 3/16" to 1½". Our engineers welcome an opportunity of prescribing a type or types which will best serve you. Special types designed to suit individual specifications.

Send now for Engineering Manual describing complete line.

Please address Dept. MD-55

SOUTHWEST PRODUCTS CO.

2705 SO. MOUNTAIN AVE. DUARTE (LOS ANGELES COUNTY) CALIF.

New Machines

stand. Both sanding surfaces can be operated simultaneously or individually. A large auxiliary tilting worktable, which tilts 45 deg, is interchangeable for use with belt or disk. A lever arrangement permits fast changing of belts without retensioning and retracking; a simplified knob control provides for adjustment of tension and tracking in seconds' time. Knob also locks securely into desired position. A hinged guard cover which encloses driven drum swings away to permit use of end of drum for sanding curved objects. Top portion of sanding disk is protected with a cast shield recessed to allow full use of the entire disk. Provision has been made to accommodate a fence assembly which can be moved across the belt and tilted 45 deg in either direction or can be set diagonally for across-belt sanding. A dust collector is available. *Duro Metal Products Co., Chicago, Ill.*

Miniature Parts Welder: Automatic machine feeds, welds, forms and cuts off 0.001-in. wire to precision specifications. Designed to weld whisker wires on diodes, it feeds wire directly from the reel and welds it to the top or side of the pin. Wire may be formed to a specified U or S-shape and cut off at either a 30 or 45-deg burr-free angle. The end of the wire is held to within ±0.005-in. radius of the pin centerline. *Federal Tool Engineering Co., Cedar Grove, N. J.*

Heavy-Duty Grinders: Two machines, developed for accurate grinding of shear blades, knives and flat surfaces at high production rate, have capacities ranging from 60 to 296 in. workpiece length. Grinding wheel spindles are 5 and 6½ in. in diameter. Table drives are hydraulic with dual cylinders and mounting which eliminates all piston sag and worktable vibration and chatter. Standard table speeds are 10 to 120 fpm. Hy-Power model has 30 or 36-in. diameter segmental grinding wheel chucks. V-ways are 5 in. wide; flat ways, 3 in. wide. Big 60 Hogger employs a 60-in. diameter grinding wheel with patented Periphery Segmental type mounting. Wheel is made up of 40 large abrasive segments alternately mounted. *Hanchett Mfg. Co., Big Rapids, Mich.*

Processing

Vacuum Melting Furnace: Suitable for moderate size production of high-purity metals or for experimental and pilot scale work, model 436 vacuum furnace has a melting capacity of 50 lb of steel or other metals. Chamber is a horizontal cylinder 4 ft in diameter and 4 ft long. A full-opening hinged door provides access to the interior of the chamber for charging, maintenance or installation of additional equipment. When closed, chamber and door mating surfaces are sealed by an O-ring. Entire chamber is water-jacketed. A 3-in. vacuum lock located in the upper portion of the shell of the chamber contains a bucket which holds alloying materials to be added during melting. Also used for vacuum sintering, furnace has a sintering area 6 in. in diameter by 10 in. high. *Stokes Machine Co. Inc., Philadelphia, Pa.*

Casting Machine: Rotational casting machine for

The ability of a Fellows Gear Shaper to cut teeth-against-shoulder gears with complete precision control permitted more economical and weight-saving, one-piece design!

Thanks to the Fellows Method . . . you have more freedom in the design of gears and other parts that will improve the performance of your products.

Fellows Gear Shapers have the versatility to turn out unusual contours . . . special gears, ratchets, splines . . . triangular, square and hexagonal holes. You design it . . . the standard Fellows Gear Shapers can be easily adapted to cut it . . . within close tolerances . . . within reasonable production budgets.

Ask any Fellows Office for the latest facts about Fellows Gear Shapers, Shavers and Inspection Instruments.

For more freedom in the design of gears and other parts, write for our complimentary booklet: The Art of Generating with a Reciprocating Tool.

THE Fellows GEAR SHAPER COMPANY

Head Office and Export Department: 78 River Street, Springfield, Vermont

Branch Offices: 319 Fisher Bldg., Detroit 2 • 5835 West North Avenue, Chicago 3 • 2206 Empire State Bldg., New York 1

6214 West Manchester Avenue, Los Angeles 45